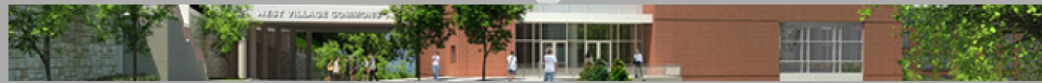
AE 482/897G **FINAL REPORT**

Towson West Village Commons

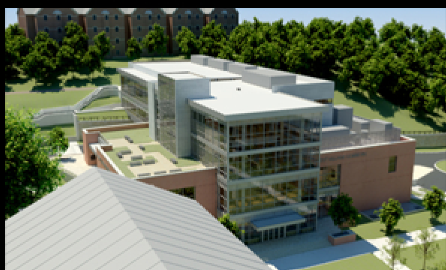
Towson University
Towson, Maryland

Advisor: Dr. R. Mistrick, Prof. T. Dannerth | Author: Patrick Morgan | April 7, 2011



WEST VILLAGE COMMONS

TOWSON, MARYLAND



PROJECT TEAM

Architect:
GWWO Inc./Architects
Civil Engineer:
Site Resources
Construction Manager:
Barton Malow
Food Service Consultant:
Ricca Newmark Design
Geotechnical Engineer:
Schnabel Engineer
Interior Design Consultant:
PLDA
Landscape Architect:
Mahan Rykiel Associates
Lighting Designer:
Bruce Dunlop Lighting Design
MEP Engineers:
James Posey Associates
Structural Engineer:
Restl Design

PATRICK MORGAN

Lighting/Electrical Option
http://www.engr.psu.edu/ae/thesis/portfolios/2011/pmm5040

UNIVERSITY MASTER PLAN

Planning Principles
A. Build Maryland's Metropolitan University
B. Develop the campus to the responsible capacity of the land
C. Create a compact, connected and comprehensible campus
D. Develop a more sustainable campus
E. Define clear edges and centers

ARCHITECTURE

Features
- Full amenity student commons
- Daylit study lounge
- Natural pathway entry to each floor
- Outdoor roof garden overlooking campus
- Signature entrance to the west side of campus.

BUILDING STATISTICS

Size
- 86,339 sq. ft.
Cost
- $30,528,000
Levels
- 5 levels, 4 above grade
Construction Dates
- July 15, 2009 to May 31, 2011
Delivery Method
- Design-Bid-Build

Minimal Rating of Leed Silver

ELECTRICAL

Substation
- Single ended provided inside the building
Emergency Power
1) 150 KW Natural Gas Generator
2) Quick connection available for rental generator up to 2000 KW
Primary Building Circuit
- 480/277V, 3 phase system
Secondary System
- 208/120V, 3 phase system
- Transformers located throughout the building.

MECHANICAL

Air Handling Units
- 5 Rooftop units serve floors 2-4.
- 2 Modular units serve the kitchen and first floor
Cold Water System
- 300 ton rated chiller and cooling tower.
Hot Water System
- 2 Gas Fired 3,000 MBTU/hr

STRUCTURAL

Foundation
-Spread footing on natural soil Rammed Aggregate Piers and compacted fill.
North Wing
-Concrete columns and beams and bearing walls support reinforced concrete slabs.
South Wing
-Steel beams extend from the footers to support the bridge.
Bridge
-Steel Beams span the bridge and provide transition from the concrete columns to steel columns.

Executive Summary

Towson West Village Commons is a newly constructed dining and residential building at Towson University. The facility houses various spaces that are made for the students to enjoy. The building thrives on its goal to lead Towson in a new direction and make living on campus fun. Through various building technologies, the building will reach LEED Silver certification at minimum and will offer a standard for the future expansion of Towson University.

This report is a final submission report for the AE Senior Thesis Studio. The main topic of this report covers the lighting redesign of 5 key spaces throughout the building; the Lobby and Grand Stair, the HRL Suite, the Roof Terrace, the Multi-purpose room, and most importantly the student lounge. The lighting redesign was based around the concepts of the buildings integration of natural materials and natural spaces and the desire to offer a facility that students will want to occupy throughout their collegiate career at Towson. Throughout the day and night, the lighting environment will look to mirror the outside conditions giving new meaning to the indoor environment.

In addition to the lighting redesign, electrical design work has also been conducted to reflect the changes in lighting. Additional electrical design work was conducted to analyze the current distribution system for arc fault evaluations, short circuit analysis and load flow study. Along with this electrical analysis, a hand calculation of short circuit current and protection coordination was also conducted. Another depth explores the possible integration of a DC based power distribution into the building to meet 9am to 5pm office loads. To compliment this analysis, a structural breadth is presented to see if the photovoltaic system needed to power the DC system can be mounted within the confines of the existing roof.

For the Integrated Master's Program, a depth studies the impact of automatic shading and other glazing options for the study lounge. The study lounge has the potential to be continually lit by pure daylight throughout the day. Glare levels were determined and set as the goal to reduce the possibility of glare from daylight. In addition, dimming sensors are analyzed for their impact on potential energy savings. To coincide with this analysis, a Radiant Times Series Model was developed for the space under the various daylight models run.

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Acknowledgments

I would like to thank the AE faculty for their continued support through the years and helping me to reach this level in my education.

Thank you to Dr. Richard Mistrick and Dr. Kevin Houser for their continual help in and outside of the classroom to help make my collegiate career a success.

Thank you to the building team that worked with Towson West Village Commons, especially Bill Melluish, lead architect and Derrick Foster, construction manager.

Thank you to James Posey Associates for their continual support throughout this project and by providing me with an excellent opportunity to begin my career under the supervision of Thomas Clippinger and Patrick Marquez. Both were integral components to my completion of this report.

Thank you to my friends and classmates for their continual support through the years, especially within the past few months in completing thesis.

I would especially like to thank my mother for continuing to move forward. She has been a key part in my continuing education at Penn State and making sure that my dreams became a reality.

This project and completion of both my MAE and BAE degrees are dedicated to the loving memory of my father and grandfather whose dedication and commitment allowed me to move forward and achieve my dreams without hindrance.

Introduction

Towson West Village Commons is unique in its initial design as it works with the surrounding environment, while providing a unique building for the campus. Considered the west entrance to Towson University, the building incorporates Emerson drive into the building. The basement, first, and second floor are relatively smaller than the third and fourth floor, making room for an underpass for Emerson drive. This incorporates the hillside into the third and fourth floor providing a natural pathway into and out of every floor.

Inside of the building, each floor is unique in its intended function. The first floor provides retail food sales along with other building support spaces. The second floor is dedicated to an open style buffet food commons for university students, faculty and staff. The third floor, which spans over Emerson Drive, offers office space, a small fitness facility and open study/lounge space. This floor also offers access out into a garden. This garden acts as a meeting space and the roof for part of the second floor. The fourth floor is predominantly dedicated to a multipurpose room and the second tier of the student study/lounge space.

Connecting the first and second floors and also the study lounge tiers are grand staircases. Main corridors are kept primarily on the east side of the building. The glass found on the third floor study lounge and along the east hallway face into the center of campus. The views create a place where the vision for Towson can be easily experienced. Whether coming through the underpass, enjoying the roof garden, or enjoying the study lounge, the focus remains on Towson University.

Building Information

Project Information

- Building Name: Towson West Village Commons
- Location: Towson University, Towson Maryland
- Occupancy: Non-Separated Mixed Use (Type A-2, A-3, B, Utility)
- Main Function: University food commons for students and faculty of Towson University.
- Size: 86,339 sq. ft.
- Levels Above Grade: 4 levels
- Total Levels: 5 levels

Design Team

- Architect: GWWO Inc./Architects
- Civil Engineer: Site Resources
- Construction Manager: Barton Malow
- Food Service Consultant: Ricca Newmark Design
- Geotechnical Engineer: Schnabel Engineers
- Interior Design Consultant: PLDA
- Landscape Architect: Maham Rykiel Associates
- Lighting Designer: Bruce Dunlop Lighting Design, LCC.
- MEP Engineers: James Posey Associates, Inc.
- Structural Engineer: Restl Designers

Sustainability Features

According to the University Master Plan, all new construction will strive for LEED certification. Using LEED version 2.2, West Village Commons is estimated to be awarded at least Silver Status. Most credits will be determined by material use and construction methods. Existing trees will be preserved as per detailed plans provided by the landscape architect. An intensive green roof serves as a roof garden on the 3rd floor and helps to manage some water drainage. Water management for the site is a high priority due to the building relationship with an adjoining hill. The 3rd and 4th floor study lounge optimizes the use of fritted, translucent and clear low-E glass to provide daylighting to the space. The overall building is not daylight compliant due to its highly unusual shape and location. The metal panel exterior and high albedo roofing material prevent a heat island effect by the building.

Inside of the building, lighting fixtures were chosen based on energy usage and low flow fixtures were used in restrooms and other locations throughout the building. Fluorescent light sources were used as a way to reduce energy consumption in the building. An energy model was developed, and while a large portion of the façade was glazing, the building still reduced its energy consumption by 22% when compared to buildings of a similar nature.

Communications

The system branches from the campus feed for Towson Run Apartments. The system enters the building through Boiler Room 001 and is distributed through the building with cable trays until eventually reaching individual telecom closets. Cabling is consistent with the category 6 cable for data outlets. Voice outlets will utilize category 5E cable. Between telecom rooms, the cabling will consist of 12 strand single mode and 12 multimode fiber optic cable for data and 100-pair cable for voice. Racks found in each telecom room will tie into the main telecom room, room 117. This also houses the telephone switch. Almost every room will have a telephone and data connections. A coaxial audio/visual system will also be employed in most rooms.

Construction Management

The CM at Risk management technique was used to help the university guarantee a maximum cost for their project. For Barton Mallow, CM at Risk offered many benefits for both LEED certification and construction scheduling. The primary focuses of the project were time, budget, and LEED accreditation. Since Towson Run Apartments and other residence halls will be in use, it is imperative to minimize the construction impact on student living. Because of these constraints, Barton Mallow chose to schedule using milestones and use two bid packages for subcontracting work. The milestones were effective ways to condense the site area and minimize construction impact. The bid packages allowed for fast startup on the concrete and steel placement along with keeping site workers to a minimum.

As with LEED accreditation, building materials and construction management were a big influence. Onsite is a 60" Oak tree that must be maintained throughout the construction process. Close work between the construction manager and the landscape architect was required to avoid damaging the tree. Between site preservation and logistics, an estimated 9 LEED points can be obtained for this project. Towson University has been happy with the less than 2 year construction time and GMP of around $31,000,000 for the efforts to improve the campus while minimally affecting the campus.

Electrical

West Village Commons uses a fairly simple radial distribution system to supply power throughout the building. Only one 2000A main switchboard is required to power the building. Focused around the electrical room found in the basement, 480Y/277V, 3Ph, 4W and 208Y/120V, 3Ph, 4W systems run throughout the building. Transformation between power systems occurs in the basement with either pad mounted or wall mounted dry-type transformers. The 480Y/277V system primarily services the mechanical, lighting and snow melting loads. For the rest of the loads, a 208Y/120V system is in place. 208Y/120V power is also in place for the rented retail food spaces. Many of the panel boards are protected by main circuit breakers along with other systems being protected by enclosed circuit breakers.

In case of emergency, an outdoor 150kW natural gas generator can supply power to life safety, standby and elevator loads through automatic transfer switches. In the case of a long term power disruption, a 2000A quick connect switchboard can be used to bring power into the building. This quick connect switchboard is located outside of the building and has the ability to supply both Towson Run Apartments and West Village Commons. The power available to the West Village

Commons building form the generator is tied directly into the main 2000A switchboard, so all loads are carried.

Fire Protection

The buildings fire protection is branched off of the domestic water connection made in the boiler room in the basement. This services both sprinklers and fire hose cases on each floor. At certain points in the building, including the roof, there is a 2-1/2" fire hose connection to provide quick connection for firefighting services. Based around a control panel found at the second floor vestibule, the fire alarm system has various monitors, pull stations and strobes and speakers located throughout the building. To set off those systems, various smoke and heat detectors are located throughout the building. The fire alarm system ties into the elevator controls and access controls for various door locations.

Lighting

Towson West Village Commons set out to be a signature building on the west side of campus at Towson University. The building's LEED accreditation and stunning design is to impress visitors, students and faculty. The use of recessed fixtures proves a dominance of the architecture. Lighting is adequate in most spaces with a few enhanced spaces. The student lounge is a premiere spot and the latest lighting technology is employed to bring color and "pop" to the space. As seen by all students from the quad, the exterior of the building looks in on this spectacle of light.

After analyzing the current conditions, the lighting scheme has both high and low points but does achieve one primary goal, energy efficiency. Along with a minimal lighting power density, controls are a stand out feature for most of the spaces. The general spaces are tied together through a building digital control system. This allows for programmed scenes and varying lighting uses depending on the occupant. The multipurpose room on the fourth floor is especially interesting from a control stand point. The space can be controlled through one panel for a single lecture hall or the complete 8,000 sq. ft. space.

Mechanical

The mechanical system is based around seven variable air volume air handling units. The seven air handling units serve various areas in the building. Certain units handle entire floors, while one dedicated unit handles the office spaces. The seven air handling units, 5 roof mounted and 2 interior serve over 90 separate supply grilles. Because of the kitchens found on the second floor, 100% outdoor air is required to exhaust certain pieces of equipment. Two make up air units are found on the roof of the second floor on the west side of the building. Each of the make-up air units can exhaust over 4,500 cfm. Spaces such as telecom closets and dry storage are served by an independent ductless split system. Along much of the glass curtain wall system, a perimeter finned heat radiation system provides heat to offset the loads of the air handling units in those spaces.

To serve all of these systems, domestic water is supplied to the building. Once reaching the building, a chiller and two gas fired boilers generate either the hot or cold water needed to serve the different systems. To further reduce the energy, a 300 ton induced draft counter flow upblast cooling tower is employed. The chiller is also rated as a variable flow 300 ton chiller system. The two boilers are specified to be gas fired 3,000 MBH units.

Structural

There are two distinct structural systems used to support West Village Commons. The primary super structure for the North end of the building is poured and precast concrete. Most columns throughout the north end are either 24" x 24" or 24" in diameter. These columns are supported by a substructure made of spread footers and grade beams. The grade beams once again conform to the 24" x 24" size. Footers and grade beams use a 4,000 psi concrete mixture while columns and slabs use a 5,000 psi concrete. Typically a 9" floor slab will be seated on a concrete column with the addition of a 7 1/4" thick drop panel. For additional strength and safety concerns, the elevator shafts and stair wells are 12" thick shear walls, using 5,000 psi concrete. All slabs, beams, columns, and walls are reinforced using various rebar sizes and counts.

The south end of the building uses a steel moment frame to bridge over Emerson drive. The steel is joined to concrete footers in the hillside at the south end. From these steel columns, steel beams project out towards the north end of the building. Due to the curvature of the underpass, there is no typical steel beam size. W36 and W24 sized steel provides the base level structure above the underpass. A composite slab of 3-1/4" reinforced concrete and 2" 20 gauge composite steel decking sits on top of the composite steel beams. All column and beam connections use a double angle shear connection. To tie the building together, steel beams sit on the outermost reinforced concrete columns and are connected with shear studs.

Transportation

West Village Commons has a unique experience when traveling through the building. Every level exits out of the building. The third and fourth floors use the newly constructed hillside path as both a means of egress and a landscape element to the building. The second floor exits out onto an existing path along Emerson drive. While traversing through the building, there are many ways to venture from floor to floor. The grand stair is a signature element to building and is primarily used by students entering from the quad. As one reaches the third and fourth floors, the grand stair is no longer available. A replica of the grand stair can be found in the student lounge at the north end of the building. Two stairwells are located in the interior of the building for occupant use to go from the basement to the fourth floor. Elevator A is located within the kitchen space and is sized for delivery usage. Elevators B and C are primarily for occupant use.

Grand Stair and Lobby

Lighting Redesign

Space Description

The most important element for the West Village Commons is its connection to the surrounding student residencies. The quad, at the north end of the building, is the primary focus of West Village. Through the use of a glass façade, the quad translates into the building. Once in the building, an occupant faces a highlight element of the Commons building. Initial ceiling height when entering the building is 11'-5". The "cloud" ceiling is made of acoustical ceiling tile and is framed to hang lower than the exposed structure above. One a few feet into the space, the ceiling lifts to a height of 30'-6" above the first floor. The grand stair focuses on creating a great rise in the building. Some at Towson could relate this to the new growth and expansion of the University in this area. This building, especially the stair speaks volumes about the new outlook of Towson University. Through the use of wood, stone and suspended cloud ceiling, the transition from outdoor to indoor is accomplished extremely well. The stone covering the stair rises 18'-0" until reaching the second floor. The stone stairway also creates a unique study space underneath at the first floor level.

Table 1: Grand Stair Materials

Material	Location	Brand	Product Number	Reflectance
Stone	Floor	Noce Tavertine	Local Supplier	0.16
Wood 1	Walls	Eucalyptus Wood	Local Supplier	0.27
Wall 3	Walls	Painted Gypsum (PT-3)	Sherwin Williams SW7537	0.63*
Ceiling 7	Ceiling	Armstrong	#3906	0.90
Exposed Ceiling	Ceiling	Paint (PT-2)	Sherwin Williams SW7076	0.88

**Based on comparable color with available product data.*

Table 2: Glazing Properties

Glazing	Type	SHGC	Transmittance	Reflectance
Railing	Clear	N/A	84%	8%
GL-3	Clear	0.38	70%	11%
GL-4	Translucent	0.37	60%	12%

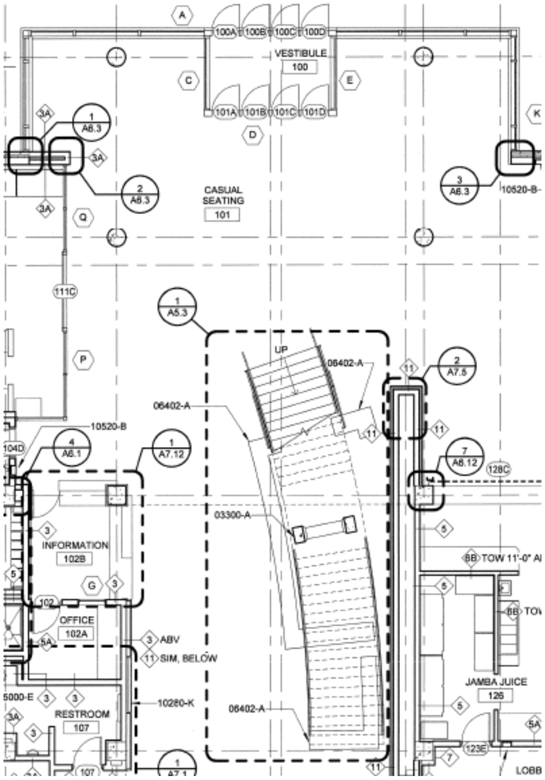


Figure 1: Floor Plan

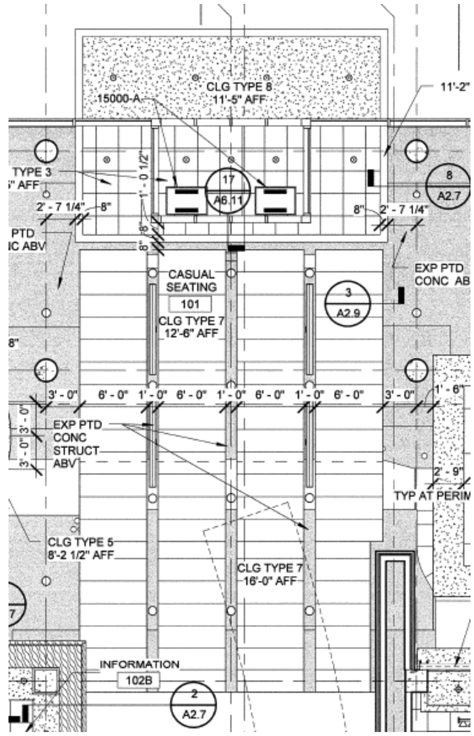


Figure 2: RCP Level 1

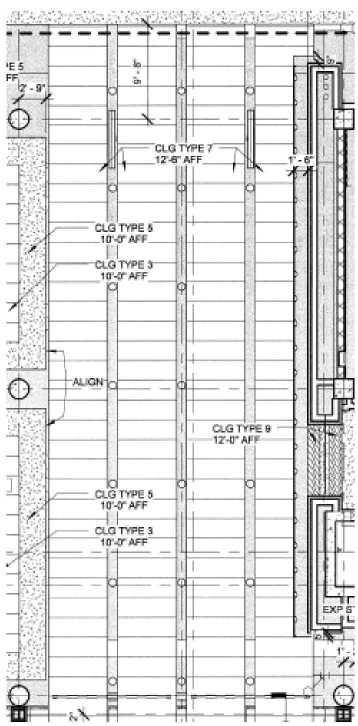


Figure 3: RCP Floor 2

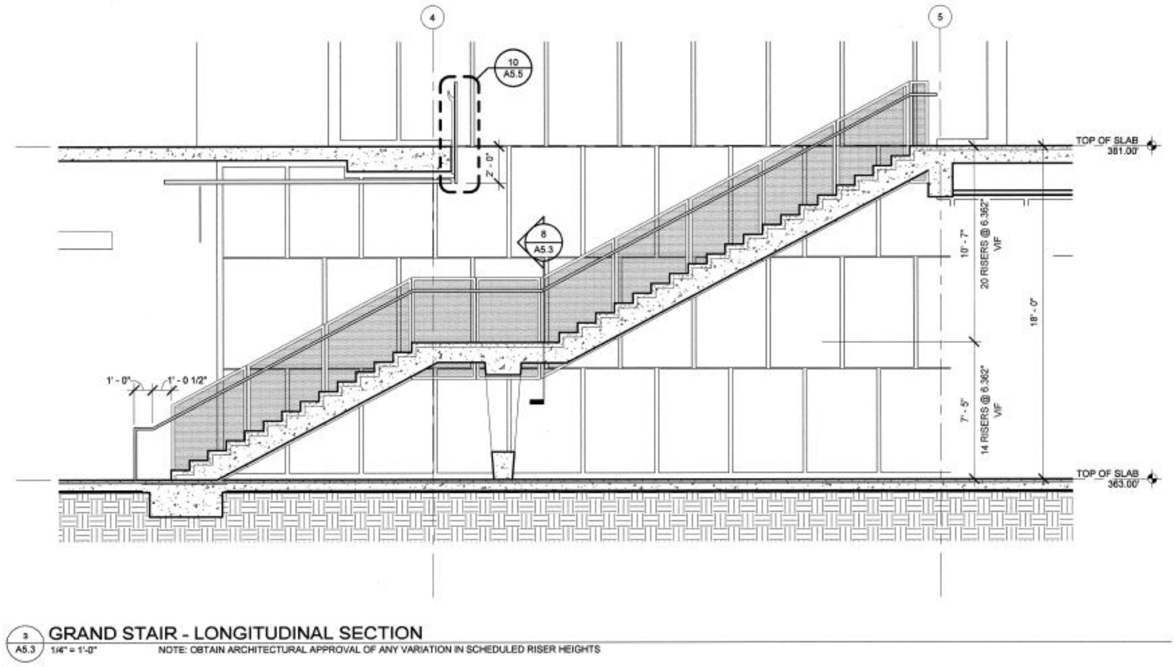


Figure 4: Stair Elevation

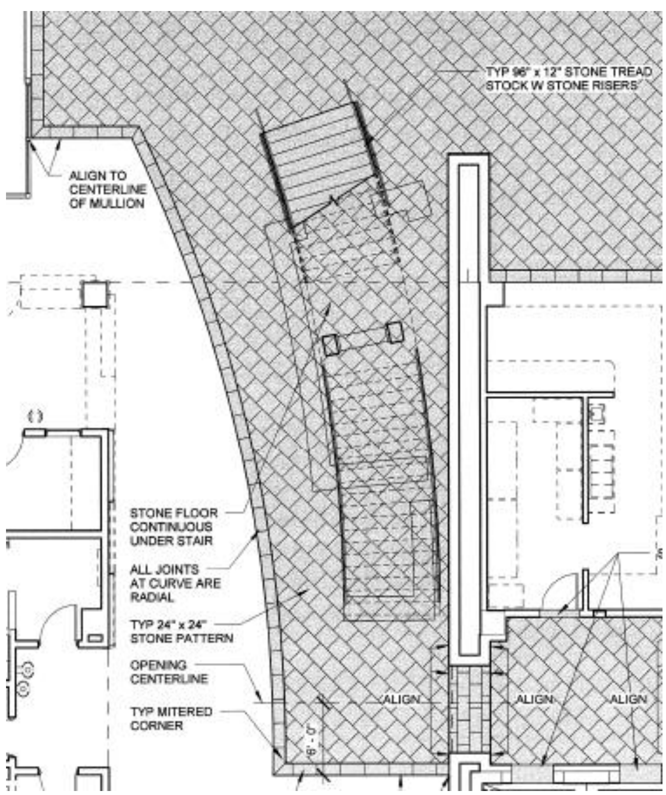


Figure 5: Stair Finish

Space Function

As students approach from the West Village Quad and adjacent residence hall, the 1st floor lobby is the primary entrance to the building. Once entering the lobby, the ceiling height increases, driving students and visitors deeper into the space. Once through the entrance, the lobby opens up revealing the stairs, media wall, information desk, and seating areas. Students can study in the seating areas, traverse the stairs for commons food services, and catch up on the latest news and events. This focal point of the building will be accessed everyday by students and will be the considered the first impression on the interior of the building. Additionally, this space will need to be accessed 24 hrs. a day throughout the school year.

Design Criteria

The Grand Stair is more than just an element to connect two floors. Because of its location, it becomes the primary focus of the building. From a classification standpoint, it must have elements of both a lobby and still be a safely lit stairway.

IESNA Categories: Lobby, Stairways and Corridors.

Very Important

1. ***Appearance of Space and Luminaires***

   Because the grand stair is a focal point of the building, it is important that the luminaires blend in with the architectural elements, especially the "cloud" ceiling.

2. ***Color Appearance (IESNA)***

   Texture is the key component of the grand stair. The stone and wood, while transitioning the building, need to be highlighted. The color of each texture should be enriched by the light, and rendered almost as if it was under daylight. CRI > 85.

3. ***Shadows (IESNA)***

   A primary safety concern for stairways, shadows should be reduced so that all stairs are visible. If a stair is in shadow, it can become a tripping point causing injury to building occupants.

4. ***ASHARE 90.1-2007 Power Density:*** 1.3 W/sq. ft.

   Because of the LEED accreditation, it will be important not to exceed the ideal power density in order to apply for reduced energy loads.

Important

1. ***Direct Glare (IESNA)***

   Direct glare can be blinding and detrimental to those trying to traverse the stair. To handle this problem, luminaires should be hidden or at least lensed so that direct glare from the lamp is not created.

2. ***Light Distribution on Surfaces (IESNA)***

   Such as with shadows, a uniform light over the stair is important in traversing the stair so that no tread is missed. Evenly lit surfaces also reduce the chance at reflected glare.

3. ***Modeling of Faces and Objects (IESNA)***

   With the high volume of traffic through the lobby, it is important to note the personal interactions happening through the space. Stopping to have a conversation or to arrange a meeting, lighting will be needed to render faces well. Warm CCT, < 3500K, with a CRI of +85 will light space adequately.

4. ***Reflected Glare (IESNA)***

   Light reflecting off of the stair can be highly distracting and can lead to trouble traversing the stair.

5. ***Horizontal Illuminance (IESNA)***
   a. Stairway: 5 fc
   b. Lobby: 10 fc

6. ***Maintenance***

   Because of the great heights within this area of the building, long lamp life and protected, sealed luminaires will eliminate some factors of dirt and lumen depreciation.

Design Overview

Concept

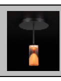
One of the key architectural features of the building is the “cloud” ceiling. Integrating the feeling of spaciousness and sustainability, clouds hang at various levels throughout the space. To further develop this concept, between the clouds will be fluorescent lighting to act as a light coming through the clouds. This will provide the general illumination within the space, as daylight in outdoor spaces. In areas that are exposed to the structure above, small compact fixtures can apply light without drawing attention to them. Additionally in the lobby space, the wood wall can be highlighted to enhance the texture. With focus being on the media wall, lighting will be carefully placed so that it does not impact a viewer’s ability to comfortably view the screen. The lobby information desk should also draw attention through the use of small pendant fixtures.

This lighting concept works well for when the facility is in use during the day. During the evening, the outdoor environment changes and provides a new scene. To meet the ideas of transitioning between night and day, pin point decorative sources can be added to act as “stars” within the space. Additionally column lighting will highlight the height of the building. Through the glass façade towards the quad, the stars and columns can become the backdrop rather than a building.

Lamp/Luminaire Selection

When trying to mock daylight, a high CCT would be used. Because of the use of wood and stone, the textures would look very bland. With wood especially, lamps should be selected within the 3000K range or lower. To meet both daylight and the textures, a 3000K lamp will be used within the wall grazing fixtures and a 3500K lamp will be used in the downlights. Since the 3000K is not being used other than on the surface of the wall, mixing color temperatures will not be an issue. With selecting a proper linear fluorescent to fit between the "clouds," the concept of using a louvered fixture was developed. At 12', the clouds will seem as though they are a continuous ceiling. The louvered downlights will look as though they are a skylight. At greater heights, such as 28,' the louvers will not be as pertinent, and the clouds will be well defined. To create the pinpoint sources, LEDs were chosen based on purpose and energy usage.

Fixture Schedule

Luminaire		*Classification*	*Mounting*	*Lamp*		*Ballast*	*Voltage*	*Watts*	*Description*	*Fixture*
S1		2'-0" Color Changing LED Strip	Surface Mounted	Integrated LED	RGB LEDs	N/A	120	35	2' RGB LED strip with 10 deg by 60 deg beam spread. Indoor Rated. Internal Driver for 120V connection.	Philips Color Kinetics 2-RED-GREEN-BLUE-10x60
S2		4'-0" Direct Flourescent Pendant	Pendant Mounted at Adjacent "Cloud" ceiling Height	GE F32T8/SPX35/ECO	3500K, CRI = 86	Advance VEZ-132-SC	277	35	4' Linear Parabolic Downlight with one piece 0.09" thick aluminum body. 1.5"H x 2.5" frequency prabolic louver. Reflectro with semi-specular finish. 277V electronic dimming ballast.	Focal Point FW1-PL-1T8-1C-277-E-RC-WH-4
S3		4'-0" Wall Mounted Wall Grazer	Wall Mounted: See Detail	GE F32T8/SPX30/ECO	3000K, CRI = 86	Advance VEL-2P32-SC	277	38	4' Linear Cove fixture. 20 gauge steel housing and 24 gauge reflector. High Reflectance White Power Coat on Reflector. 277V electric ballast.	Focal Point FW1-PL-1T8-1C-277-E-RC-WH-4
S4		4'-0" Wall Mounted Wall Grazer	Wall Mounted: See Detail	(2) GE F32T8/SPX30/ECO	3000K, CRI = 86	Advance VEL-2P32-SC	277	58	4' Linear Cove fixture. 20 gauge steel housing and 24 gauge reflector. High Reflectance White Power Coat on Reflector. 277V electric ballast.	Focal Point FW1-PL-2T8-1C-277-E-RC-WH-4
S5		7" CFL Surface Mounted Downlight	Surface Mounted to Exposed Ceiling	GE F32TBX/835/A/ECO	3500K, CRI = 82	Advance IDL-2S26-M5-BS	277	36	7" Round Housing White Finish, 0.05" thick aluminum. One Socket 277V Electronic Ballast	Portfolio C170-32-2D32-W-7050-W
S6		4.5" x 4.5" Recessed CFL Wall Wash	Ceiling Recessed	GE F26TBX/830/A/ECO	3000K, CRI = 82	GE GEC226-MVPS-BES	277	29	4.5" x 4.5" Recessed Wall Wash with 0.125" thick micro prism lense. Reflectance finished in High Reflectance White coating. One piece die-cast construction. 277V electronic ballast	Focal Point Housing: FC44-26TT-S-277-SF-T Trim: D44-SF-WWMG-CD-WH
S7		9" Cylinder Single LED Pendant	8'-0" Above Finished Floor	Integrated LED	3000K, Warm White	N/A	277	4	Aluminum construction with galvanized backplate. Acrylic Diffuser colors to include black and yellow. 277V Driver.	Winona LED LED-POPS01-9-CYL-L-001/HO-ND24V
M2		6.75" x 6.75" Recessed CFL Downlight	Ceiling Recessed at 14'-0" A.F.F	GE F32TBX/830/A/ECO	3000K, CRI = 82	Lutron EC3D T4MW K U 1	277	27	One piece die-cast 6.75" square frame. Trim to provide 25 degree cutoff from view of lamp. Painted white flange finish. 277 V with electronic ballast.	Focal Point Housing : FC66-32TT-S-277-SO-T-D66 Trim: D66-SO-DN-WH

Light Loss Factors

Values for luminaire dirt deprecation were generated from AE 464 coursework. This is for all spaces. Except for the terrace, LLD will be clean environment cleaned at 12 month intervals. LEDs lamp lumen depreciation was set at 0.8 based off of AE 561 course work.

Table 3: Lobby Light Loss Factors

	BF	LLD	LDD	Total
S1	1.00	0.80	0.92	0.74
S2	1.00	0.95	0.92	0.87
S3	1.10	0.95	0.85	0.89
S4	0.88	0.95	0.85	0.71
S5	1.00	0.85	0.92	0.78
S6	1.10	0.85	0.92	0.86
S7	1.00	0.80	0.92	0.74
M4	0.81	0.92	1.00	0.75

Mounting Details

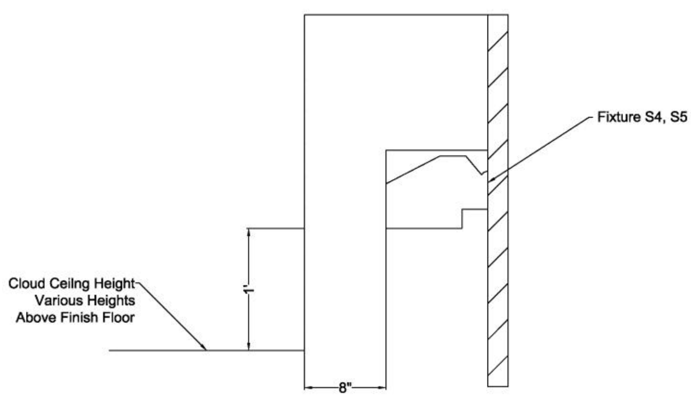


Figure 6: Wall Grazer Mounting Detail

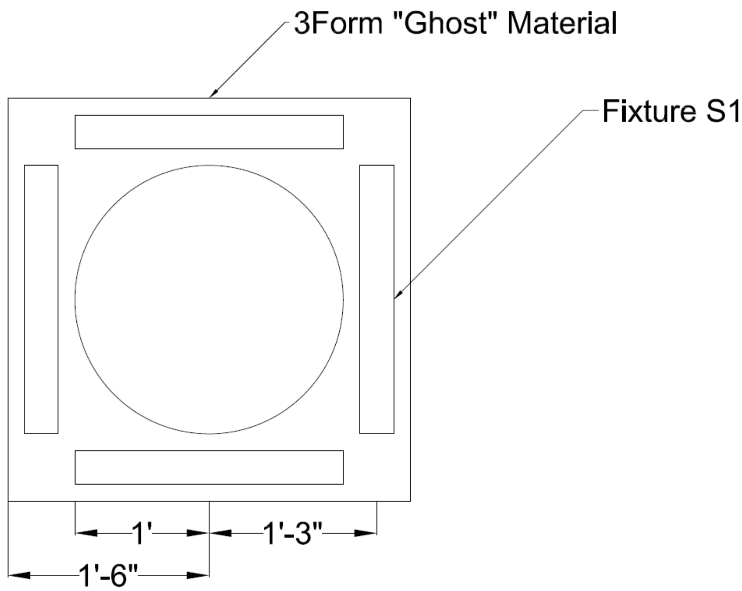


Figure 7: Column Design

Design Performance

Criteria Evaluation

Through the use of a linear parabolic fluorescent downlight, the initial cloud/daylight concept was achieved. To add some decorative lighting to the space, 3form material was used to create a 3' x 3' column around the existing concrete column. Color changing LED fixtures are surface mounted to the floor, on both the first and second levels, to uplight the columns. The technique generates an overall height of the building when viewing from the quad. 3form ghost white material has an approximate transmittance of 35%. The night sky theme developed in the concept is being isolated to the study lounge. Grazing of the 2 story wood wall adds texture to the space. Through the use of 3000K lamps, the natural glow of the wood is improved over the standard ambient lighting. Wall washing CFL fixtures highlight poster boards for local announcements. By maintaining a 10' spacing from the media wall, the overall illuminance of the surface is uniform. This can be seen through below. The overall illuminance of the lobby area at the first floor is 15 fc. The stairs were evenly illuminated to prevent any safety problems.

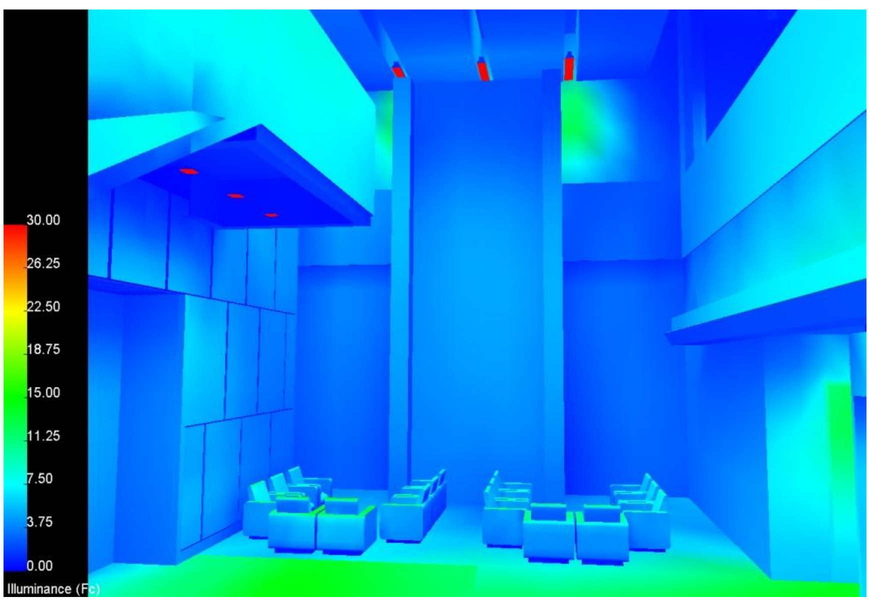


Figure 8: Pseudo Rendering of Media Wall

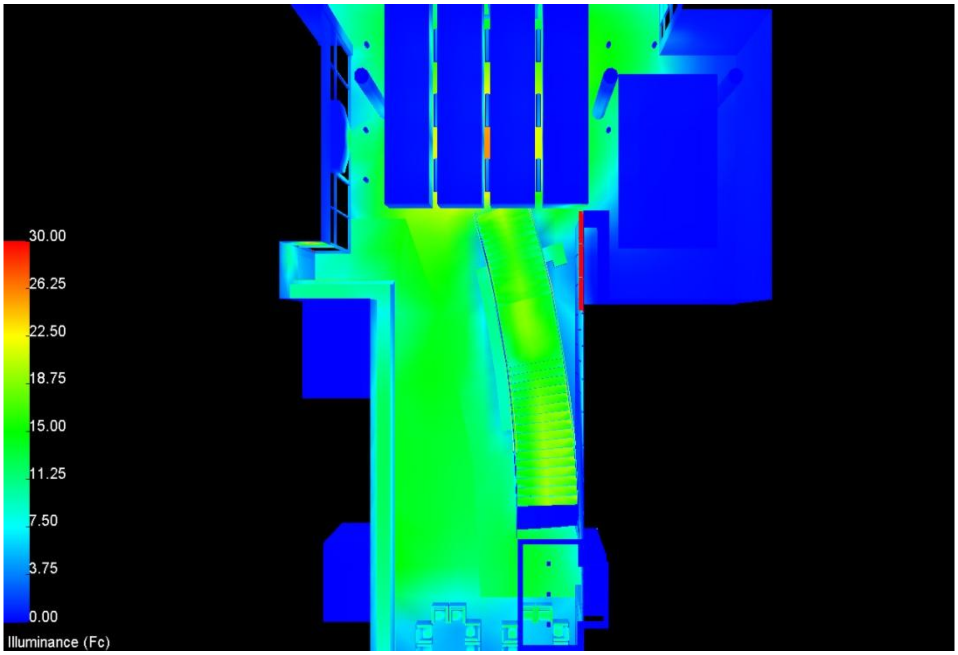


Figure 9: Overhead View of the Stair Illuminance Levels

Lighting Power Density

The lighting power density including the decorative living is 1.08 W/ sq. ft. ASHRAE 90.1 requires a minimum of 1.3 W/ sq. ft. The design was able to meet power density requirements.

Table 4: Lobby Lighting Power Density

Luminaire	*Quantity*	*Watts(W)*	*Required Power (W)*
M2	11	35	385
S1	32	35	1120
S2	36	35	1260
S3	9	35	315
S4	5	64	320
S5	12	35	420
S6	4	28	112
S7	6	4	24
		Total Power	3956
		Square Foot	3679
		LPD	1.08 W/sqft
		ASHRAE	1.3 W/sqft

Renderings

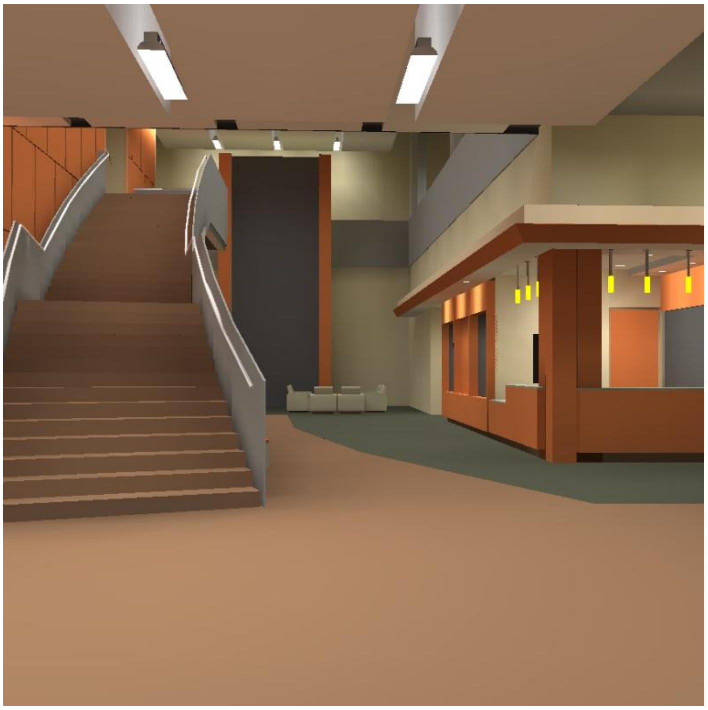


Figure 10: View of the space from the vestibule.

Figure 11: View from the Seating Area

Control System

With being the main entrance of a building, the lobby area will want to be controlled automatically. Through the use of lighting control panelboards with individual circuit breaker contacts, the system will be able to control the lighting without being seen. Additionally, areas near the windows will receive daylight and will require additional control. The use of a daylight sensor will dim the lights, when sufficient daylight is in the space. Below is the wiring schematic for the designated daylight sensor. Emergency lighting will be controlled by lighting relays. Lighting relays is placed to override the switching and provide the center row of lights to illuminate the space. Because indirect fixtures

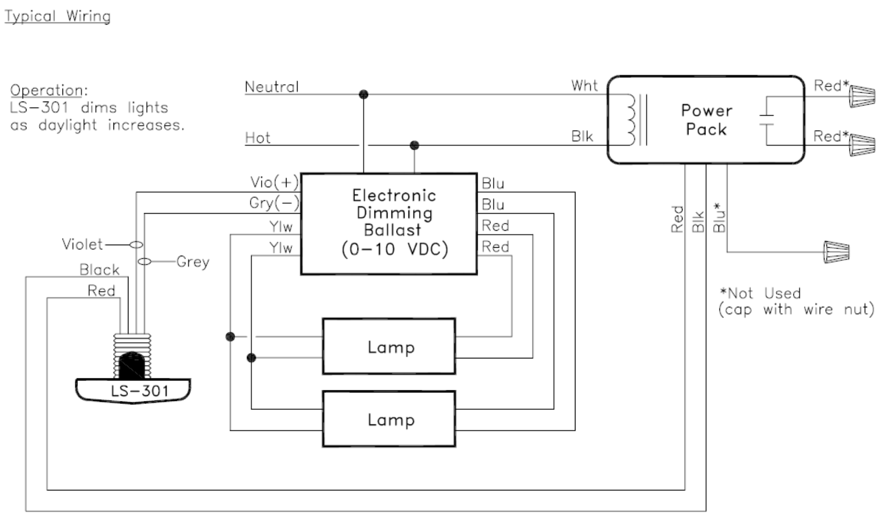


Figure 12: Wattstopper LS-301 Control Diagram

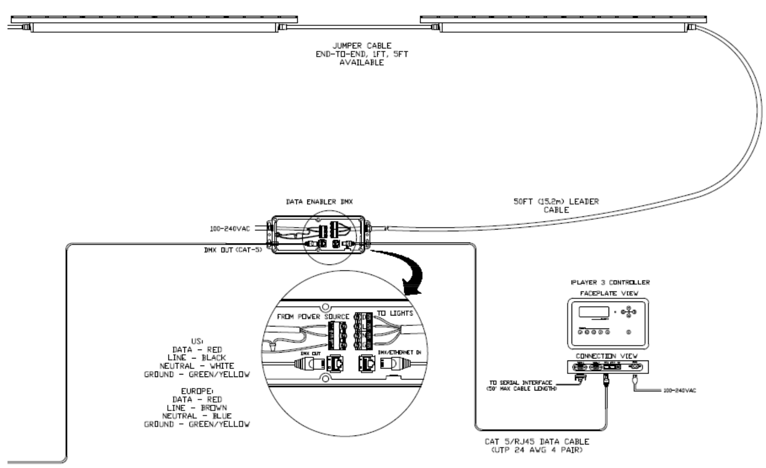
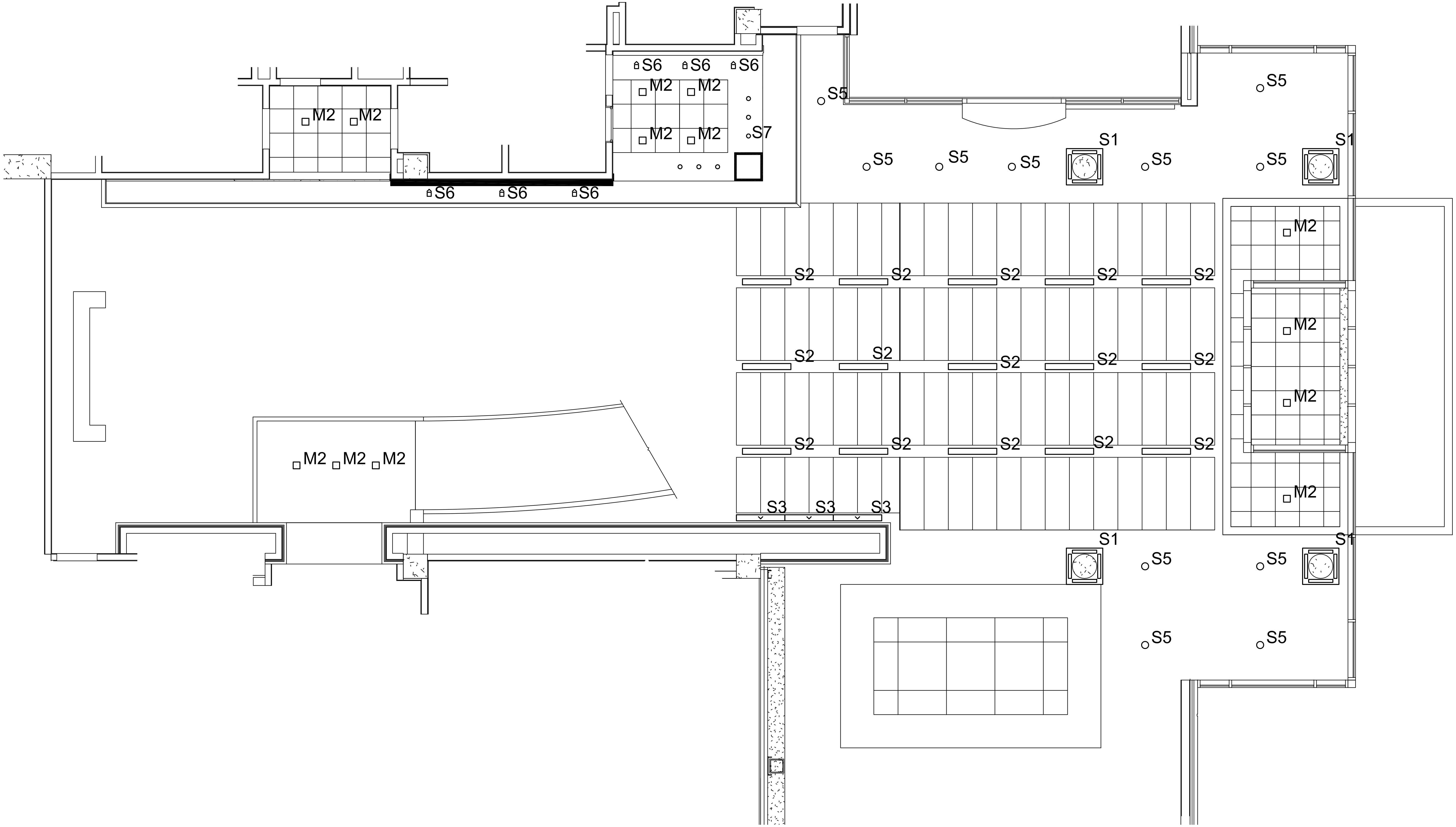


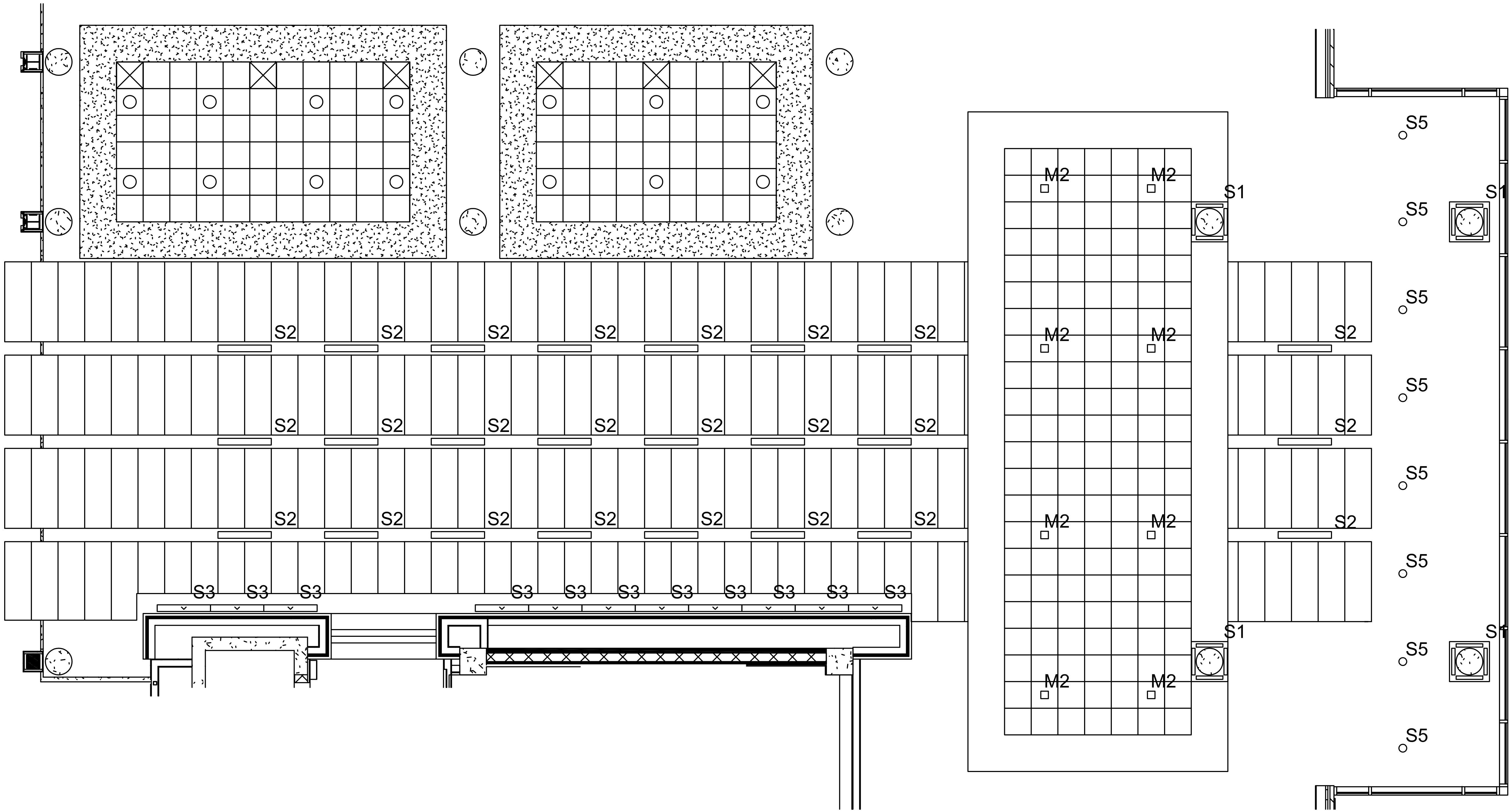
Figure 13: iPlayer 3 Control System

Table 5: Lobby Control Equipment

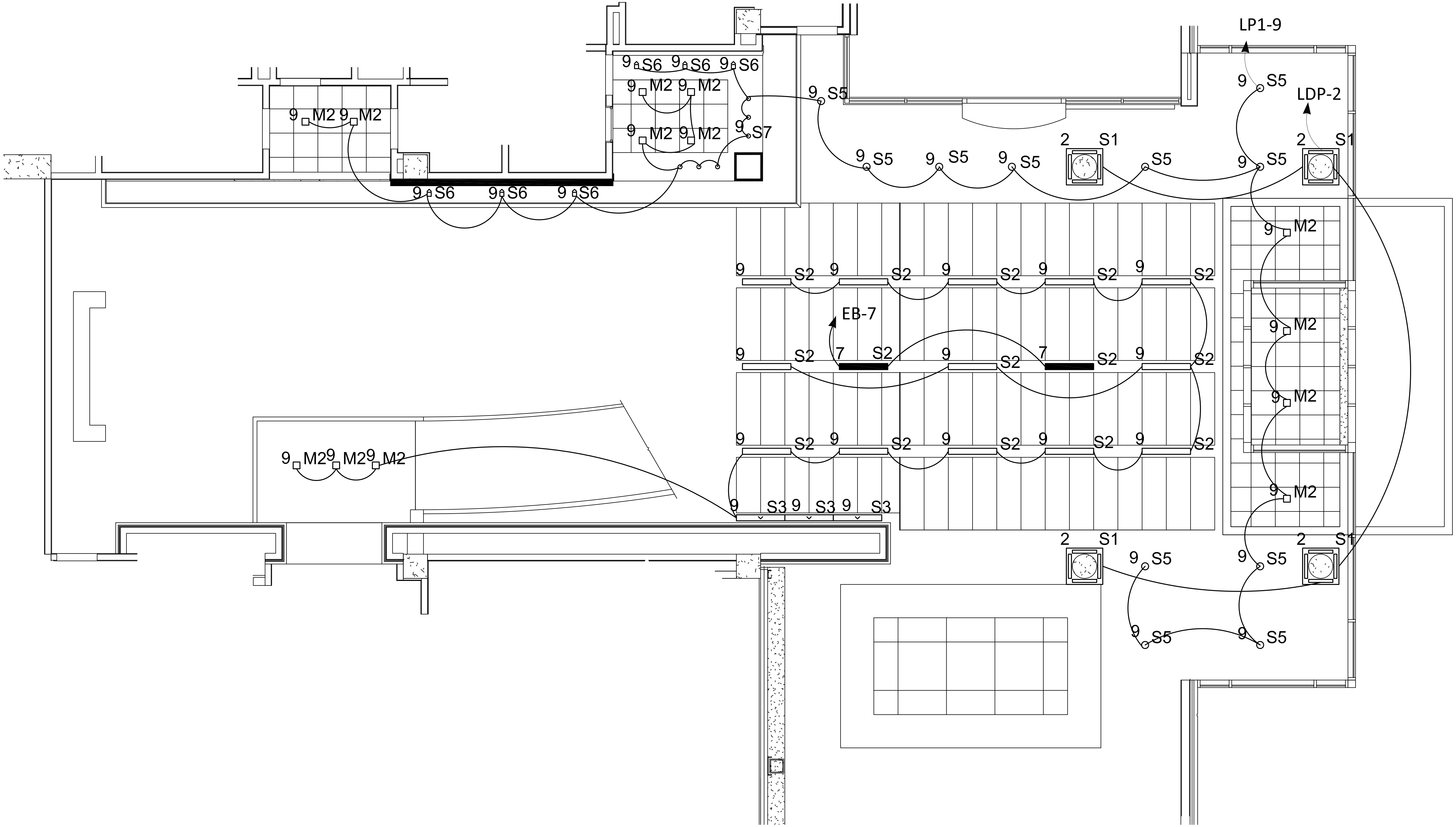
Tag	*Manufacturer*	*Catalog Number*	*Description*
C	Philips	iPlayer 3	LED controller with scene functionality and color control.
D	Watt Stopper	LS-301	24VDC Dimming Daylight Sensor mounted to ceiling at 12'-0".
ER	Philips	GTD20A	Emergency Lighting Transfer Relay. Circuit to Emergency Panel without switching. Relay shall be rated for 20-Amperes of lighting load.
PP	Watt Stopper	BZ-50	20A Load Power Pack to supply power to dimmer.



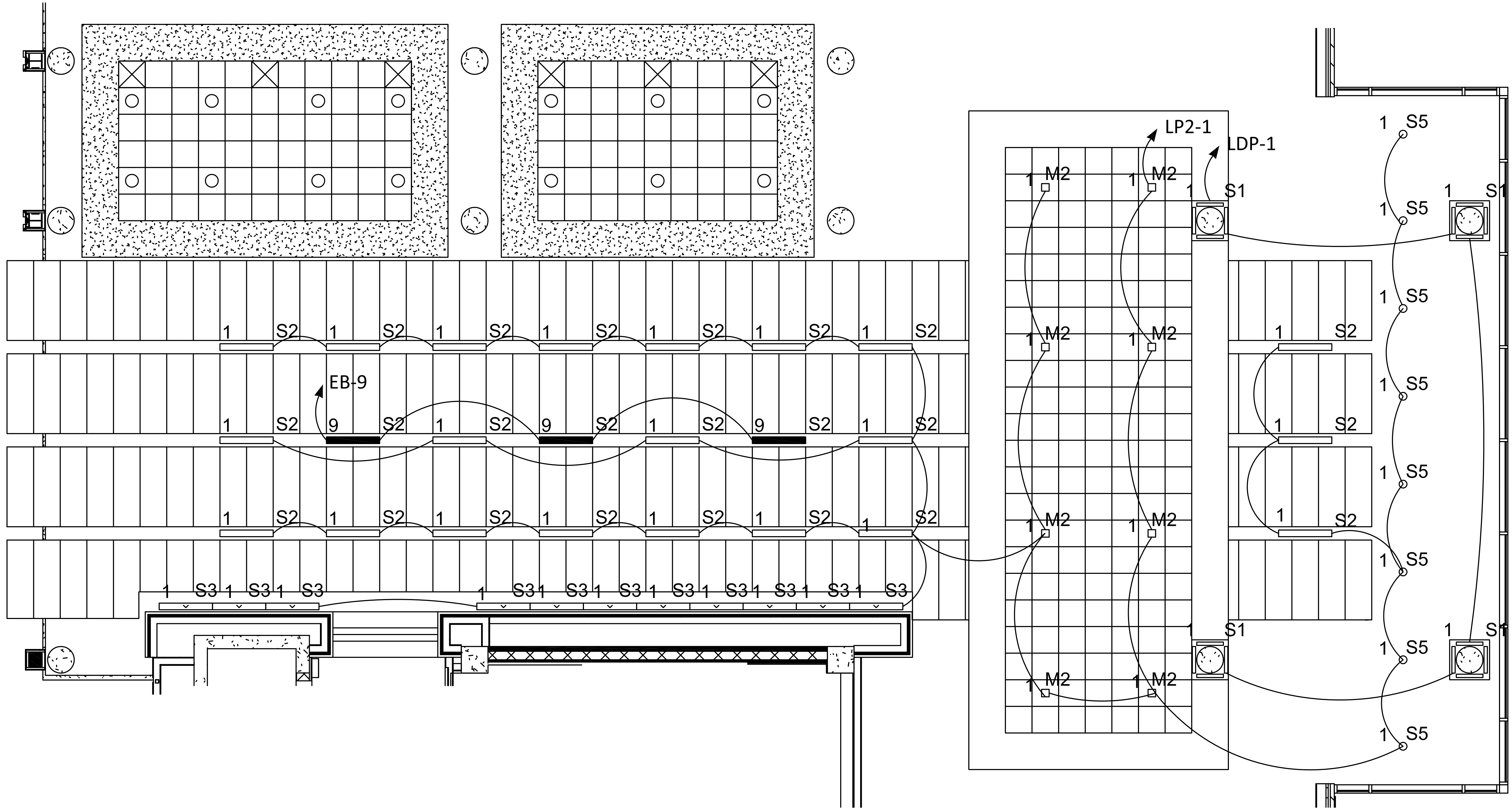
E1.1A	LOBBY LIGHTING PLAN	
	SCALE: $\frac{1}{8}$" = 1'-0"	AE 497G/882
	PATRICK MORGAN	APRIL 7, 2011



E1.1B	LOBBY LIGHTING PLAN	
	SCALE: $\frac{1}{8}$" = 1'-0"	AE 497G/882
	PATRICK MORGAN	APRIL 7, 2011



E2.1A	LOBBY POWER PLAN	
	SCALE: $\frac{1}{8}$" = 1'-0"	AE 497G/882
	PATRICK MORGAN	APRIL 7, 2011



E2.1B

LOBBY POWER PLAN	
SCALE: $\frac{1}{8}$" = 1'-0"	AE 497G/882
PATRICK MORGAN	APRIL 7, 2011

Housing and Residence Life (HRL) Suite

Lighting Redesign

Space Description

The Housing and Residence Life (HRL) Suite, Room 335, can be found in the south end of the building on the third floor. Located towards the interior of the building, the space relies solely on electric lighting for illumination. The suite is an open office work space with typical cubicle partitions reaching a height of 5'-0". Though the space can be easily reconfigured, there are two distinct non-movable elements that will require certain attention. This is an independent work counter, figure 14, and the reception counter, figure 13. Typical painted walls, acoustical ceiling tile, and carpet are used to define the space. Wood is integrated into the cabinetry and the counters use a recycled glass and concrete to further extend the goal of the HRL department to be sustainable. The ceiling is mounted at a typical 10'-0" but drops to 9'-0" to help define the difference between the HRL Suite and the HRL corridor. While there is no real need to place boundary doors, this is an effective way to partition the large open space from the occasionally used desks in the HRL Corridor. Surrounding the suite are private offices for full time program directors and assistant directors. Each office has a small set of windows looking into the space.

Table 6: HRL Materials

Material	Location	Brand	Product Number	Reflectance
Carpet 5	Floor	Mannington	Deep Thoughts, "Imagine"	0.03
Wood 1	Cabinet	Eucalyptus Wood	Local Supplier	0.27
Counter	Counter Top	Icestone	Storm Cloud	0.34
Wall	Walls	Painted Gypsum (PT-3)	Sherwin Williams SW7537	0.63*
Cubicle	Cubicle Wall	Maharam	Seasons	0.32
Door	Wall	Algoma Hardwoods	Not Specified	0.56*
Ceiling 7	Ceiling	Armstrong	#3906	0.90
Soffit	Ceiling	Painted Gypsum (PT-4)	Sherwin Williams SW7566	0.88*

**Based on comparable color with available product data.*

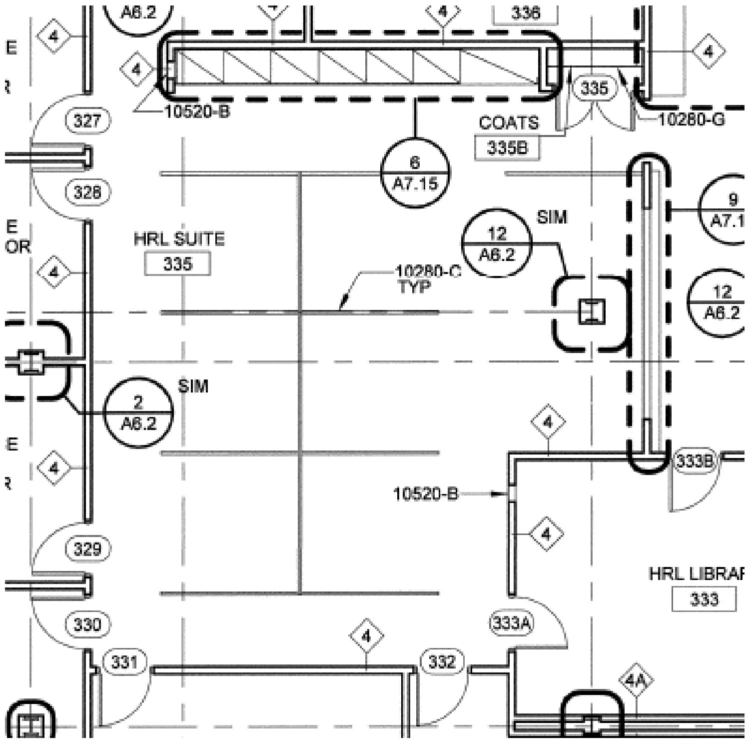


Figure 14: HRL Suite Floor Plan

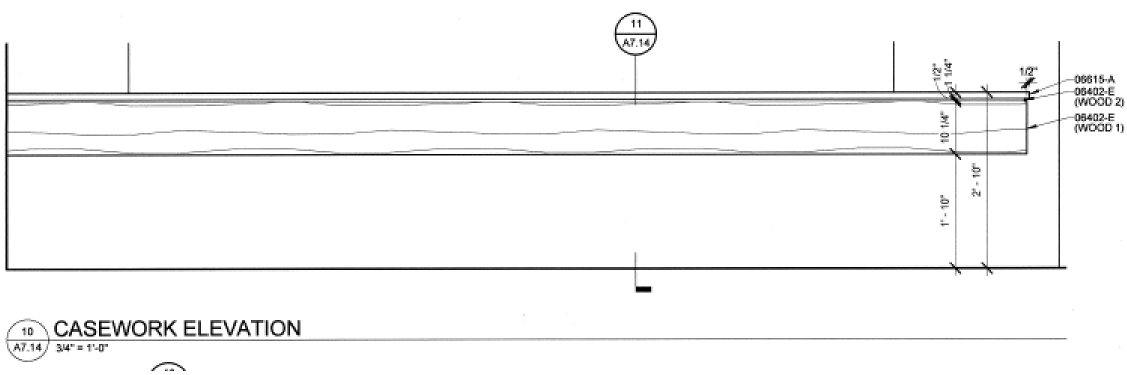


Figure 15: Reception Counter

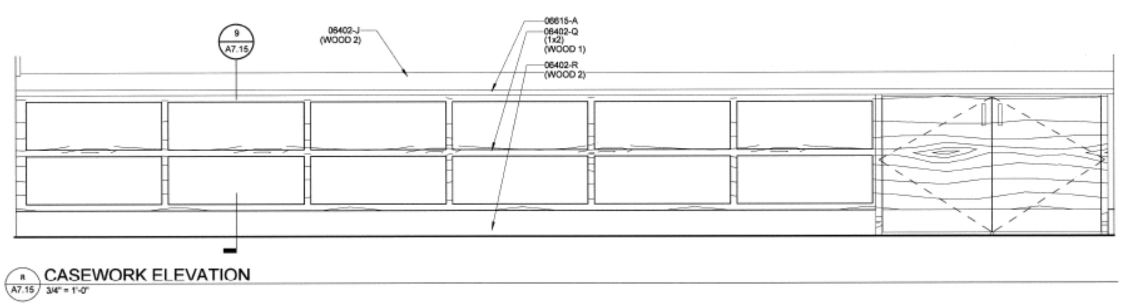


Figure 16: Work Counter Elevation

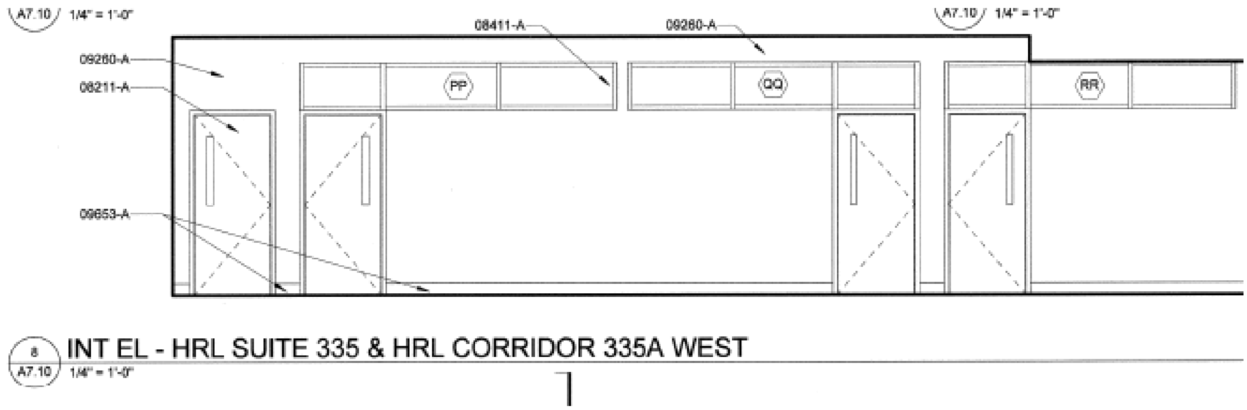


Figure 17: West Wall Elevation

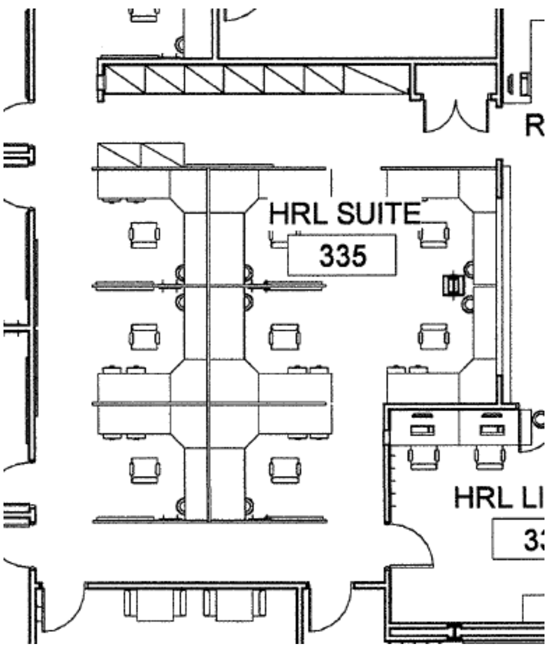


Figure 18: Furnishing Plan

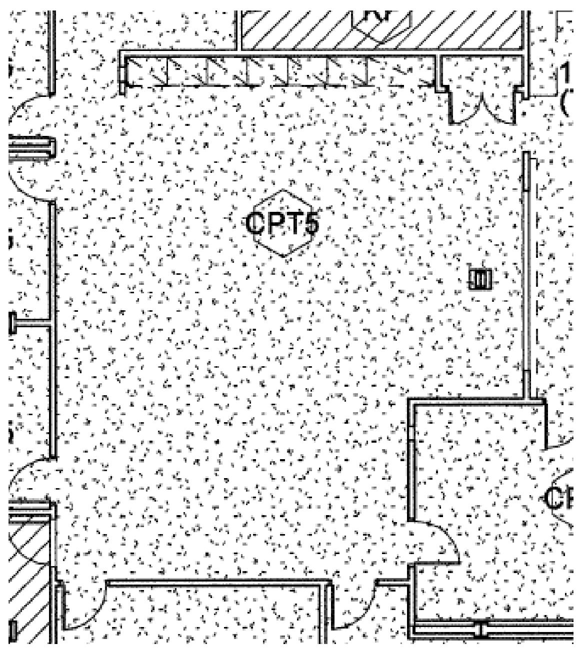


Figure 19: Finish Floor Plan

Space Function

The purpose of the HRL suite is to act as the primary office to run all operations within the West Village Community. The open office plan must be handle daily computer use along with reading, writing and other daily office tasks. Because of cubicle design, task and ambient lighting is to be combined and focused over the work space. Ambient lighting will be the primary source of lighting to offer a feeling of spaciousness in this interior environment. As more and more tasks become computer based, the lighting can be reduced to accommodate for the constant VDT use.

Design Criteria

The HRL Suite is situated at the interior of the building, and requires no daylight integration. The typical open office with intermittent computer use will be the primary space studied.

IESNA Categories: Open Office Plan, Intermittent VDT, Reading: 8-10 pt print, ball point pen

Very Important

1. ***Direct Glare (IESNA)***

   For most office workers, direct glare can be not only a problem but a great source of discomfort within the office. It is very hard to control the eventual design of the office open plan.

2. ***Modeling of Faces or Objects (IESNA)***

   Working in any office, person to person contact is a high priority. Especially at the counter between the reception and suite, there is a great need for being able to accurately see the person one would come into contact with. Through lamps with high CRI and warm color temperature, a person can be rendered quite well. CRI > 85, CCT < 3500K. Lamp orientation and size also affect the ability to model objects correctly.

3. ***Luminances of Room Surfaces (IESNA)***

   While most people look down to do work, they eventually need to look up. Having a variation of luminances can disrupt the eye and cause great discomfort. Surfaces far from the work surface need to be illuminated uniformly and kept within a 10:1 luminance ratio. For the task at hand on an adjacent work surface from a VDT, a 3:1 ratio is optimal.

4. ***Reflected Glare (IESNA)***

   Much like direct glare, reflected glare can be hard to control in an open office plan. Typically problems with reflected glare arise from the use of computer screens or VDTs. To reduce this, VDTs should be arranged in a manner that the luminaire does not reflect off of the screen. Additional glare can result from a high ceiling luminance.

5. ***Source/Task/Eye Geometry (IESNA)***

   More of a broad topic, source/task/eye geometry is covered through the luminance ratios and the ability to avoid glare when transitioning between tasks.

6. ***ASHARE 90.1-2007 Power Density:*** 1.1 W/sq. ft.

   Because of the LEED accreditation, it will be important not to exceed the ideal power density in order to apply for reduced energy loads.

Important

1. ***Light Distribution on Surfaces (IESNA)***

   Because of the cubicle partitions, the light will not always fall evenly on surfaces. It is important to provide enough even spacing to reduce striations of light and dark within a cubicle. This can be achieved by using an indirect system, or a system that has a very wide spread photometric.

2. ***Light Distribution on the Workplane -Uniformity (IESNA)***

   Because of the cubicle partitions, the light will not always fall evenly on surfaces. It is important to provide enough even spacing to reduce striations of light and dark within a cubicle. This can be achieved by using an indirect system, or a system that has a very wide spread photometric.

3. ***Shadows (IESNA)***

   Depending on the geometry of the space, shadows can be created within each cubicle. The use of a very wide spread photometric or indirect system can evenly distribute light around geometric problems.

4. ***Horizontal Illuminance (IESNA)***

   a. Open Office: 50 fc

      50 fc is the recommended practice for intermittent VDT use within offices. While VDT use only requires 30 fc, reading from books or normal paper requires 50 fc and because the dominant task. Switching or dimming can resolve this problem.

5. ***Vertical Illuminance (IESNA)***

   a. Open Office: 5 fc

6. ***Psychological Impression***

   Since there are no windows and the space is very confined, it is important that the lighting system works to create a sense of spaciousness and does not play to the idea of closure.

Design Overview

Concept

Being a completely interior space, the overall feel for the lighting scheme will be spaciousness. Through perimeter lighting this can typically be achieved within an office. Unfortunately, windows into private office sit at a 7' sill height around the perimeter of the room, preventing the washing of walls. Since the constant change of student employees, the cubicles do not have above desk cabinetry. With these two driving factors, indirect/direct lighting can be employed to provide both ambient and task lighting. Additionally, the counters found around the space can be illuminated with task lighting to meet IESNA recommendations.

Lamp/Luminaire Selection

The space will optimize direct/indirect fixtures to achieve adequate task and ambient levels. Additional direct fixtures will be added to help illuminate the work counter and accent lights will accentuate the reception counter. A color temperature of 3000K was important to select because of skin tones and constant human interaction within the space. Lighting was chosen on its ability to be used on both AC and DC power distributions. A fluorescent fixture was selected due to its EMerge certification. Details about the DC distribution are found in Electrical Depth 1. The fixture schedule can be seen below in **Error! Reference source not found.**. Fixture cut sheets are found in Appendix A.

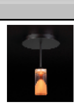
Light Loss Factors

Table 7: HRL Light Loss Factors

Luminaire	LLD	LDD	Ballast Factor	Total LLF
F1	0.95	0.92	0.88	0.77
F2	0.80	0.92	1.00	0.74
F3	0.8	0.92	1.00	0.74

Fixture Schedule

Table 8: HRL Fixture Schedule

Luminaire		Classification	Mounting	Lamp		Ballast	Voltage	Watts	Description	Fixture
F1		4'-0" Direct/Indirect Fluorescent Pendant	8'-0" Above Finished Floor	(2) GE F32T8/SPX30/ ECO	3000K, CRI = 86	Advance VEZ-2S32-SC	277	68	4'-0" 20 gauge die-formed steel frame with prepainted 91% reflective white coating with white cross blade baffles. 5%, 277V line dimming ballast.	Finelite S12-ID-WCB-4'-2T8-SC-91W-OPEN-24-FA-FE-C1
F2		6" Recessed LED Dowlight	Ceiling Recessed	Integrated LED	1100 Lm, 3000K, CRI > 80	N/A	277	19.9	6" Round Die-Formed housing with integral aluminum heat sink. Clear diffuse reflector with white painted flange. Integrated Driver.	Focal Point FL6D-11LED-L30-24-R0-T L6-R0-DN-CD-WP
F3		6" Cylinder Single LED Pendant	6'-0" Above Finished Floor	Integrated LED	3000K, Warm White	N/A	277	4	Aluminum construction with galvanized backplate. Acrylic Diffuser colors to include black and yellow. 277V Driver.	Winona LED LED-POPS01-6-CYL-L-001/HO-ND24V

Design Performance

Criteria Evaluation

The lighting design employed is based around the spatial configuration determined by the architect. Direct/indirect fixtures provide ambient light and task lighting for each of the cubicles. The work surfaces, desks and counters, are uniform in illuminance. With dimming controls, the lighting can be adjusted from 50 fc to 30 fc. The lighting layout can be found in Appendix A. Controls can be found in the electrical redesign for the space.

The designed lighting layout achieves adequate lighting on each surface. Because of the odd perimeter wall configuration, average desk light levels range between 45 fc and 55 fc. The initial design criteria recommended a level of 50 fc. Through dimming, the space can be easily adjusted to meet 30 fc when computers are in high use. The work counter light level also meets the 50 fc requirement. The reception desk will only receive 35 fc, but is not a considered a full time work surface. As can be seen below with the direct light study, only a third of light hits the desk directly, reducing the chance of glare on the VDT.

Desk Average: 45 to 55 fc

Work Counter Average: 47 fc

Reception Counter Average: 34 fc

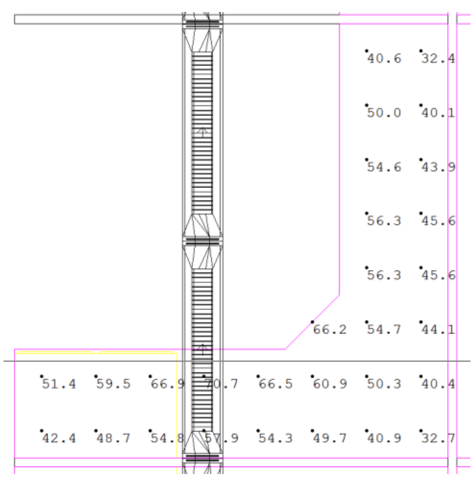


Figure 20: Typical Desk Illuminance

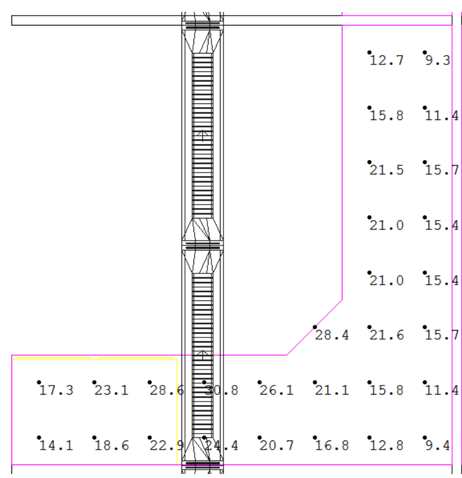


Figure 21: Direct Desk Illuminance

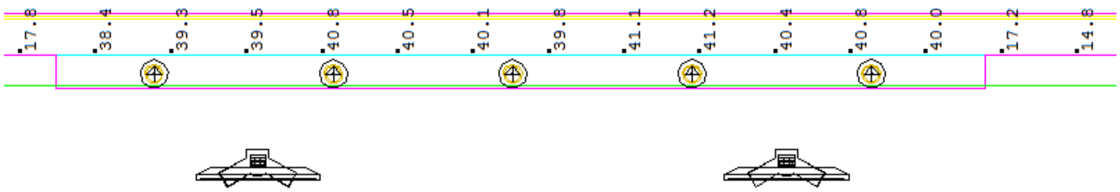


Figure 22: Reception Counter Illuminance Values

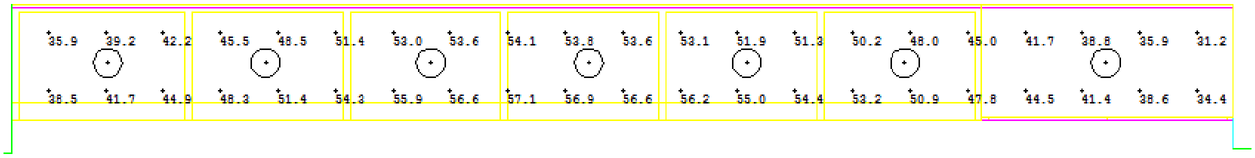


Figure 23: Work Counter Illuminance Values

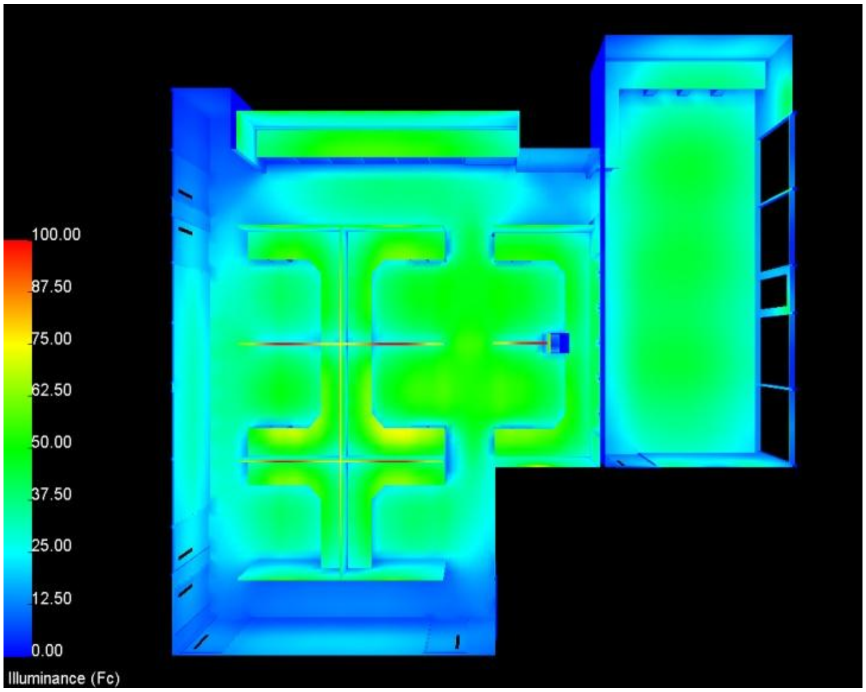


Figure 24: Psuedo Color Rendering

Lighting Power Density

The lighting power density of the space was determined to be 1.23 W/ sq. ft. ASHRAE 90.1 lists an open office at 1.1 W/sq ft. Through tradable watts between building spaces, this overage can be traded to the lobby area.

Table 9: HRL Suite LPD

Luminaire	*Quantity*	*Watts(W)*	*Required Power (W)*
F1	16	68	1088
F2	7	20	140
F3	5	5	25
		Total Power	1253
		Square Foot	1020
		LPD	1.23 W/sqft
		ASHRAE	1.1 W/sqft

Renderings

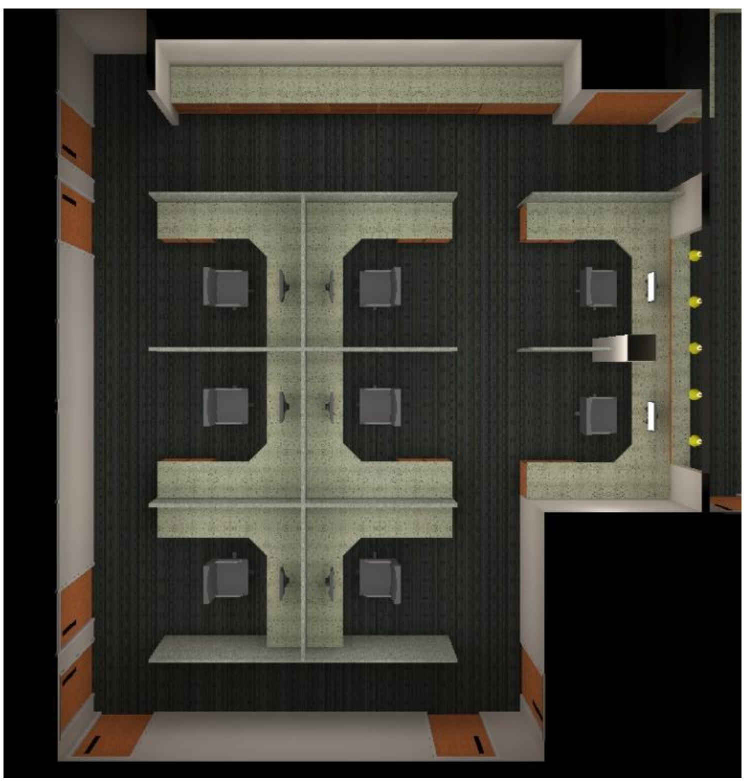


Figure 25: Suite Overview

Figure 26: Interior view of the Suite.

Figure 27: View of the Reception Counter

Control System

There are three primary zones within the suite. The work counter and pendants are turned off and on by separate single pole switches. For the rest of the office, two single pole switches can be found by the office's two entrances. Additionally, occupancy sensors are integrated into the pendant lighting to help reduce energy consumption.

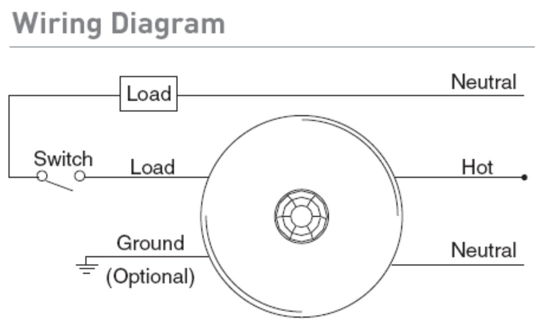


Figure 28: Occupancy Sensor

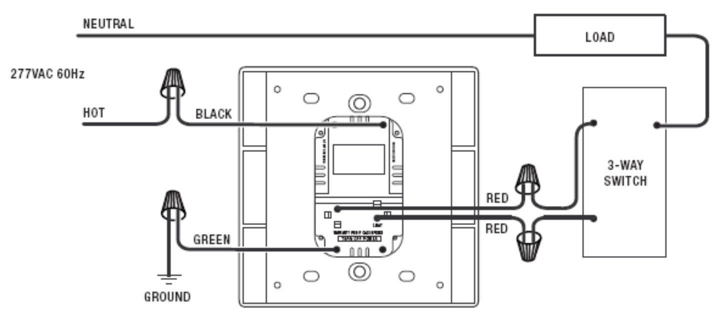
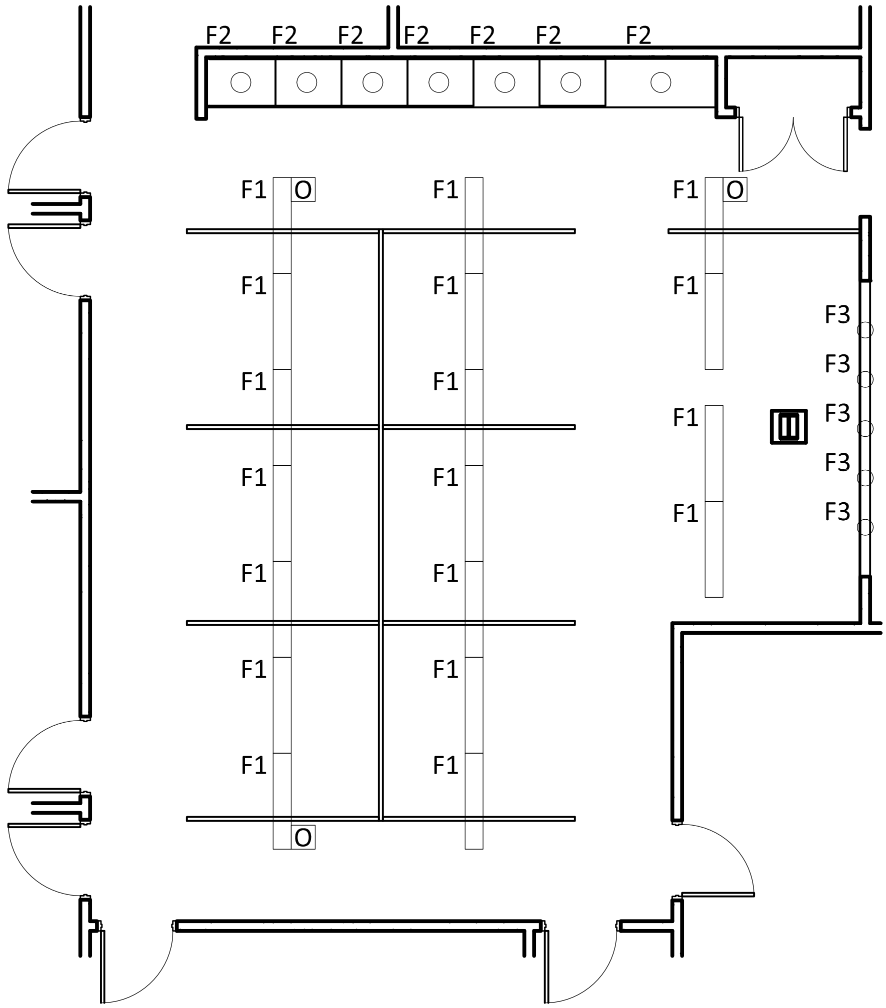


Fig. 5: Multi-way Wiring

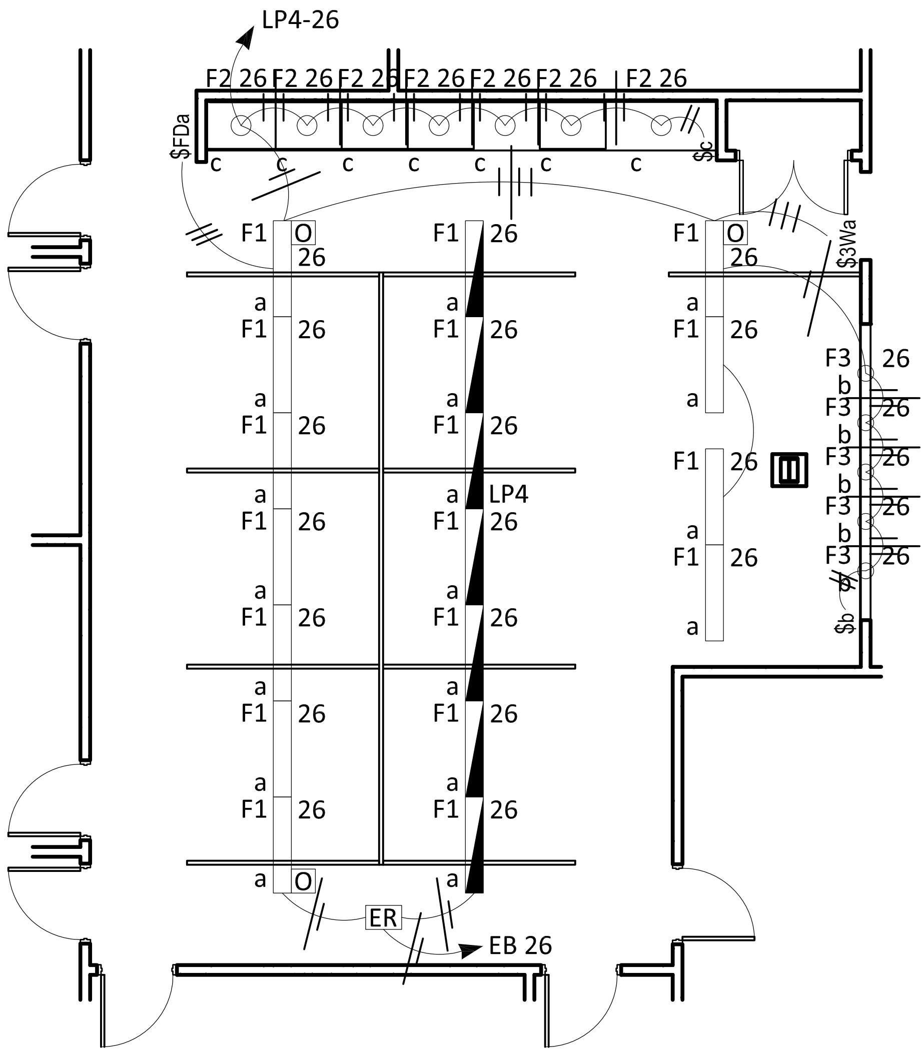
Figure 29: Dimming Switch Diagram

Table 10: HRL Suite Controls

Tag	*Manufacturer*	*Catalog Number*	*Description*
D	Watt Stopper	ADFM-10A	Line voltage, 277V, fluorescent dimmer.
O	Watt Stopper	CI-355	277 line voltage passive infrared occupancy sensor. Sensor is integrated with fixture type F1 per fixture manufacturer's specifications.
ER	Philips	GTD20A	Emergency Lighting Transfer Relay. Circuit to Emergency Panel without switching. Relay shall be rated for 20-Amperes of lighting load.



	HRL SUITE LIGHTING PLAN
	SCALE: $\frac{1}{8}$" = 1'-0"
E1.2	AE 497G/882
	PATRICK MORGAN
	APRIL 7, 2011



HRL SUITE POWER PLAN

SCALE: $\frac{1}{8}$" = 1'-0"

AE 497G/882

E2.2

PATRICK MORGAN

APRIL 7, 2011

DC Power Distribution – Electrical Depth 1

Introduction

In the Northeast region of the United States, solar technology use has been limited because of sky conditions. A typical photovoltaic array cannot typically produce enough energy within a given payback period to be cost effective. A typical system uses an inverter and can have substantial losses when the system does not work at peak efficiency. While inverters can claim up to 98% efficiency, this is usually at full output and does not use an isolation transformer. When a system is grounded, the isolation transformer is used and usually will not reach as high of efficiency. In other applications where photovoltaics can carry the loads, the concept of direct coupling is employed to reduce inefficiencies. Direct coupling is the use of a DC power source with a DC based load. With the recent development of DC based building products, direct coupling could affect the how photovoltaic systems are designed and estimated. This depth will analyze the most current technologies to design a direct coupling system. This analysis will not look at cost because some products have been recently released and price has not been market adjusted.

The primary investigation in this depth is to determine the feasibility of using a DC PV based system to power interior lighting for office occupancy. The HRL suite is a completely interior space, no windows, which will be operated during the hours of 8 am to 5 pm for all seven days of the week. Because these hours correlate to the typical sun exposure of photovoltaic, the system could potentially remove the office load from the buildings power distribution.

Lighting Design

Through the use of EMerge approved fluorescent products, the lighting design provided earlier in this report was able to be adjusted to receive DC power. The LED lighting works on 24VDC power, so the integral driver can be removed. Through the use of newly developed 2 lamp, 24 VDC ballasts, the fluorescent fixtures can be reused. The use of DC fluorescent ballasts has two primary effects. The first is reduced power consumption. Typical AC ballasts will consume 62 Watts. The newly designed DC ballast will only consume 48 Watts. The downside to the use of DC ballasts is the ballast factor. Because of the reduced power consumption, the ballast factor is recorded at 0.75. This is much lower than a typical AC electronic ballast at 0.88. By decreasing the light output, additional lighting will be required in the space. The recommendation to solve this problem is to add desk lamps. This would run off of the building's AC distribution system as a plug load. Design criteria can be changed to 30 fc, if the tasks within the office move from paper base to computer base, as it meets intensive VDT use requirements.

System Load

To size the photovoltaic array, the loading must be determined. Using an excel worksheet included with *Photovoltaic Systems, 2nd edition* [4], the loading profile for a typical day was determined.

DC LOADS

Load Description	Qty	Power Rating (W)	Operating Time (hrs/day)	Energy Consumption (Wh/day)
Luminaire F1	16	48	9	6912
Luminaire F2	7	20	3	420
Luminaire F3	5	5	7	175

Total AC Power		W
Total DC Power	933	W
Total AC Energy Consumption		Wh
Total DC Energy Consumption	7507	Wh
Inverter Efficiency	0.00	
Weighted Operating Time	**8.6**	hr/day
Average Daily DC Energy Consumption	**7507**	Wh/day

Figure 30: DC Loading

The AC system load was also determined.

AC LOADS

Load Description	Qty	Power Rating (W)	Operating Time (hrs/day)	Energy Consumption (Wh/day)
Luminaire F1	16	64	9	9216
Luminaire F2	7	20	3	420
Luminaire F3	5	5	7	175

Total AC Power	1189	W
Total DC Power	0	W
Total AC Energy Consumption	9811	Wh
Total DC Energy Consumption	0	Wh
Inverter Efficiency	0.95	
Weighted Operating Time	**8.7**	hr/day
Average Daily DC Energy Consumption	**10327**	Wh/day

Figure 31: AC Loading

The typical thought process behind the required array size is matching watts for watts. For instance, the AC system requires 1189 Watts. To design the actual AC system, the watt-hours determined above will be used. The DC system requires less watt hours per day, which results in less required number of panels.

Array Sizing and Tilt

Typically, a critical design analysis is used to determine the optimal tilt of the array. General rules are based on inverter or battery limits. For a direct coupled system, a new approach must be developed. With the use of a DC power server, AC power will back up the DC power system at any point. Because AC current is always at the optimal voltage, the current can be rectified to DC current with about 99% efficiency. A critical design analysis was developed to help determine the base standard to design to.

CRITICAL DESIGN ANALYSIS

Month	Average Daily DC Energy Consumption (Wh/day)	Array Orientation 1		Array Orientation 2		Array Orientation 3	
		Latitude - 15		Latitude		Latitude + 15	
		Insolation (PSH/day)	Design Ratio	Insolation (PSH/day)	Design Ratio	Insolation (PSH/day)	Design Ratio
January	7507	3.1	2422	3.5	2145	3.7	2029
February	7507	3.8	1976	4.2	1787	4.3	1746
March	7507	4.6	1632	4.8	1564	4.7	1597
April	7507	5.3	1416	5.2	1444	4.8	1564
May	7507	5.7	1317	5.3	1416	4.7	1597
June	7507	6.0	1251	5.6	1341	4.8	1564
July	7507	6.0	1251	5.5	1365	4.9	**1532**
August	7507	5.6	1341	5.4	1390	4.9	1532
September	7507	5.0	1501	5.1	1472	4.8	1564
October	7507	4.3	1746	4.6	1632	4.6	1632
November	7507	3.2	2346	3.7	2029	3.7	2029
December	7507	2.7	**2780**	3.1	**2422**	3.3	**2275**

Critical Design Month		
Optimal Orientation	Latitude	
Average Daily DC Energy Consumption	7507	**Wh/day**
Insolation		**PSH/day**

Figure 32: Critical Design Analysis

Because the load does not fluctuate, the ideal orientation is the latitude + 15 degrees. This is predicted to have a more even production throughout the year based on ASHRAE monthly averages for the location. The location of Baltimore, MD was used since it is within 20 miles of West Village Commons. Because of the roofing conditions, a ballast racking system will be used to mount the panels. Due to the restrictions of a ballast rack system, the maximum optimal angle that can be used is 35 degrees or roughly the sites latitude (39 degrees).

Because direct coupling through a power server does not require battery backup, the DC based array will use the max output month. There will be no inverter in the building, so over designing the system will result in power that is not used by the building.

DC system: June, 5.6 PSH/day

ARRAY SIZING

Average Daily DC Energy Consumption for Critical Design Month	7507	Wh/day
Critical Design Month Insolation	5.6	PSH/day
DC System Voltage	24	VDC
Battery Charging Efficiency	1.00	
Required Array Maximum-Power Current	**55.9**	A
Soiling Factor	0.95	
Rated Array Maximum-Power Current	**58.8**	A
Temperature Coefficient for Voltage	-0.004	/°C
Maximum Expected Module Temperature	40.6	°C
Rating Reference Temperature	25	°C
Rated Array Maximum-Power Voltage	**27.0**	VDC
Module Rated Maximum-Power Current	7.6	A
Module Rated Maximum-Power Voltage	28.9	VDC
Module Rated Maximum Power	220	W
Number of Modules in Series	**1**	
Number of Module Strings in Parallel	**8**	
Total Number of Modules	**8**	
Actual Array Rated Power	**1760**	W

Figure 33: DC Array Sizing

If an AC system with inverter were designed to this number of panels, the system, during June, would produce only 7,357 Wh/day. This does not meet the 10,327 Wh/day so additional panels or AC power would be required to run the office. The inverter system, unless on extremely clear summer days, will not produce enough energy to meet the office's needs.

INTERACTIVE SYSTEM SIZING

PV Module Rated DC Power Output	220	W
Manufacturer Power Guarantee	0.90	
Number of Modules in Array	8	
Array Guaranteed Power Output	**1584**	W
Array Average Operating Temperature	25	°C
Temperature Coefficient for Voltage	-0.004	/°C
Temperature-Corrected Array Power Output	**1584**	W
Array Wiring and Mismatch Losses	0.03	
Net Array Power Output	**1536**	W
Inverter Maximum DC Power Rating	3200	W
Inverter Power Conversion Efficiency	0.95	
Inverter MPPT Efficiency	0.90	
Inverter Maximum AC Power Output	**1314**	W
Average Daily Insolation	5.6	PSH/day
Average Daily Energy Production	**7357**	Wh/day
	7.4	kWh/day

Figure 34: AC Array Analysis

DC Performance

Using TRNSYS Simulation studio, the array was modeled to track performance through the months based on a weather file for the location. The simulation shows weekly data for December, March and June. The study of the solstices and equinox can show the variation of the systems performance throughout the year.

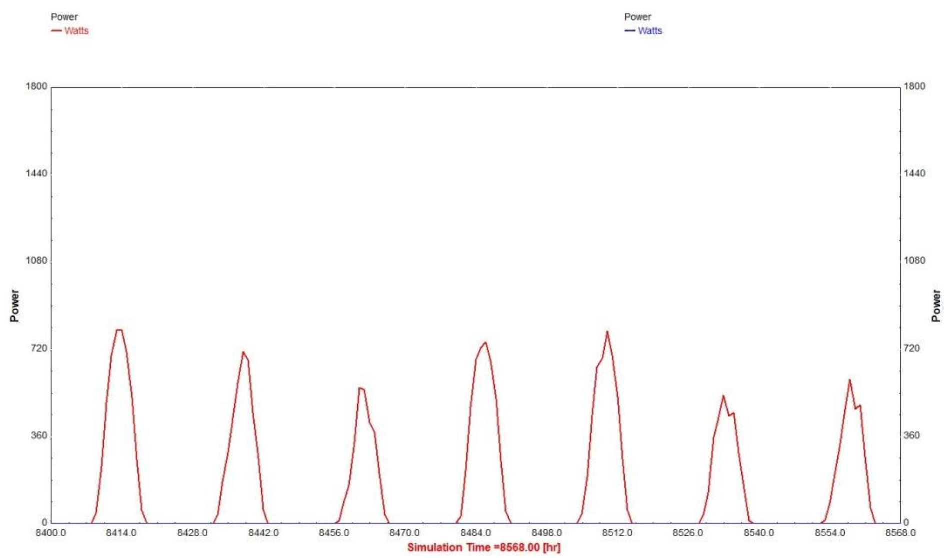


Figure 35: December Power Output

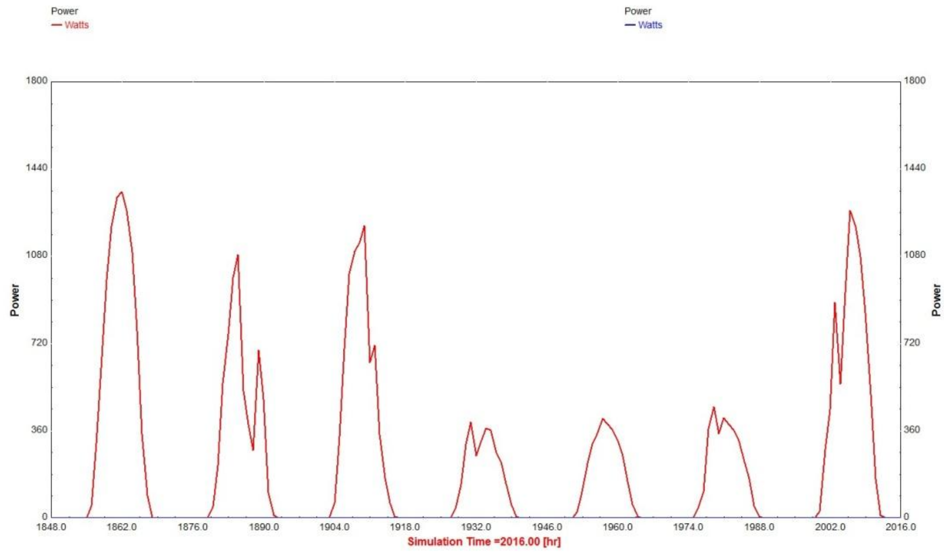


Figure 36: March Power Output

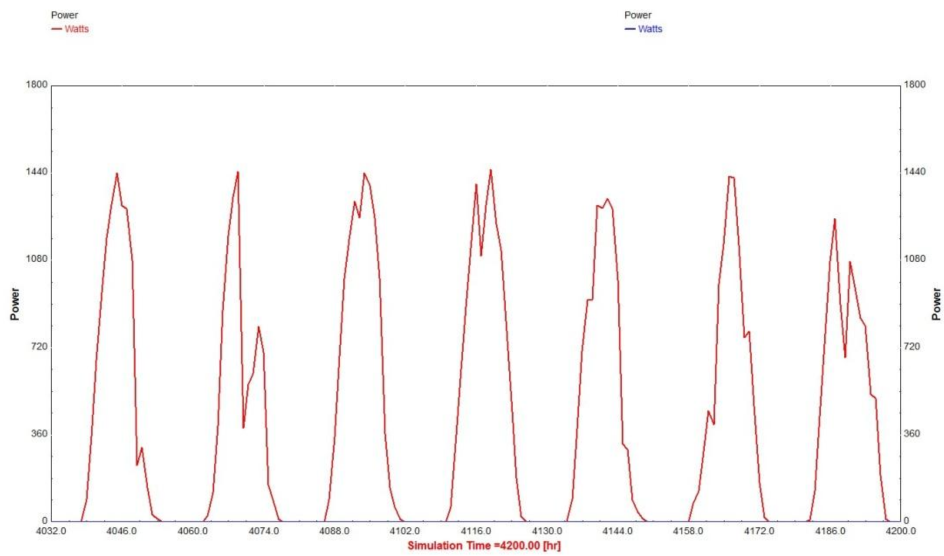


Figure 37: June Power Output

This study looked at power based on maximum power point tracking. Maximum Power Voltage in all scenarios functioned around 28V. System requirements call for 24VDC so additional regulation will be needed. A charge controller, usually found in battery based systems, could transform the voltage, but would work improperly without a battery system. Ideally the power server module that rectifies AC current would also regulate the voltage from the panels. Unfortunately the product has not been commercially released. This system, to work today, would need a battery backup system.

Power Distribution

With 24VDC, voltage drop can be a serious problem. Since the panels would be wired in parallel, a 75 ft. run from the panels to the power server. Wire is rated at 1.56 times the short circuit current which would result in a #3 gauge wire. PV wires are usually sized at 90 C.

Wire size = 1.56 x 8.2A x 8 modules = 102.4 A

Since the conduit can be run through the joists supporting the roof, no ambient temperature modifier is required. Voltage drop can be a problem and at 24VDC carrying a maximum output of 60.8A would require a wire size of 3/0. This additional wiring can be expensive.

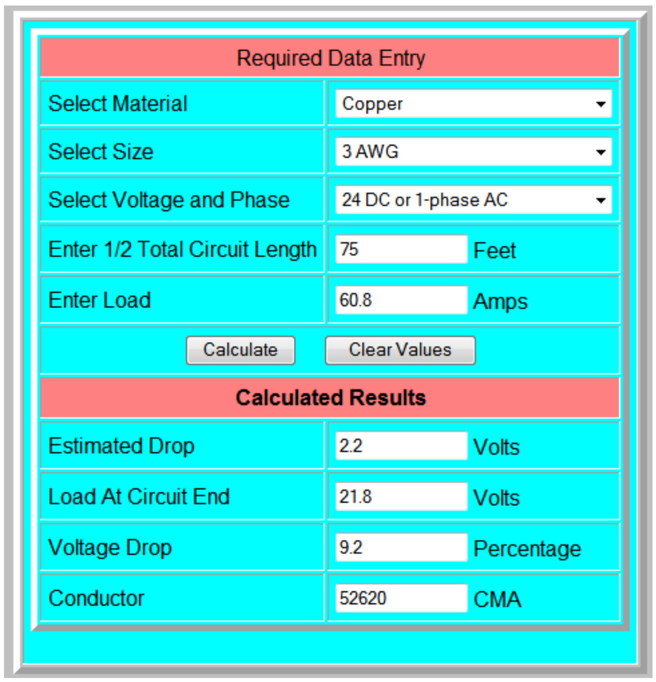


Figure 38: Voltage Drop Calculation [11]

Once connected to the power-server module, the power distribution can be made through integrated wiring within the ceiling grid. According to DC Flexzone specifications, 4.2A can be connected per Class 2 Circuit. This would account for 2 ballasts per class 2 circuit. The use of these integrated mains can reduce the clutter in the ceiling and the need for conduit.

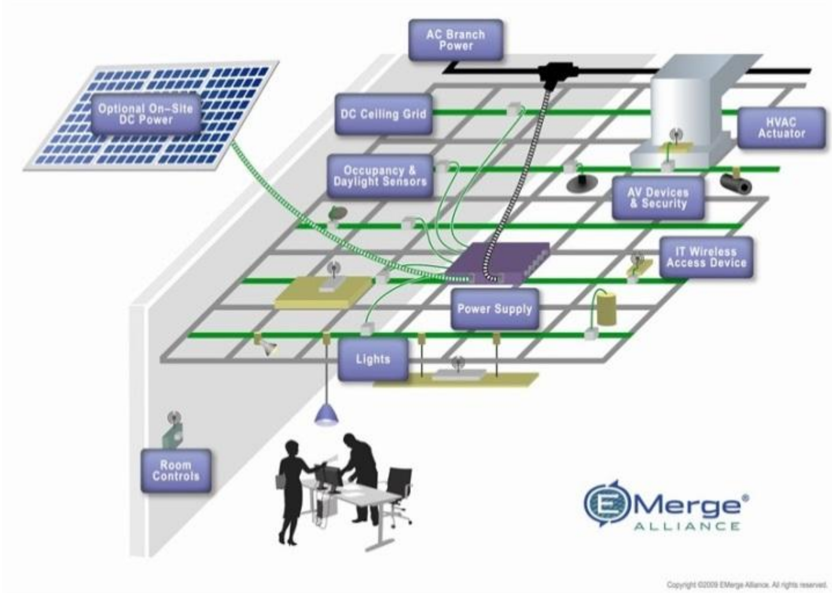


Figure 39: Power Schematic for DC System [5]

Summary

Direct coupling will allow for the use of a smaller array. While wire size increases to account for the voltage drop, power from the PV can directly input into lighting fixtures and hardware. Currently, DC power from solar is considered an optional power source. Additional battery systems are needed to create a direct coupled system. A device, made up of a transformer and maximum power point tracker, would benefit direct coupled system, so that battery systems would not always be required. The AC to DC power provides the additional current needed to power the lighting system throughout the year.

Using PVWatts Version 1, an estimated 2166 kWh would be generated throughout the year. If the system were to be run every day, 2741 kWh would be required to meet the systems demands. Because of the design approach, designing to the maximum average monthly radiation, the array should never provide wasted energy or require an inverter. The direct coupling approach is a more efficient way especially in poor solar areas to use PVs to create renewable energy. As new technologies emerge, this system will become more and more beneficial.

Breadth 1 – Structural Analysis

Introduction

After analyzing the possibility of providing photovoltaics to power the HRL Suite, the analysis will continue with the structural mounting of the array. There are several variables to take into account such as wind load, dead load, connections, and spacing. This breadth will analyze the impacts the photovoltaic array will have on the roof structure. Through methods developed in AE 404, the roof joists will be checked. Due to the imbalance of the structure, the beams cannot be analyzed without the advanced knowledge of a structural engineer. The existing air handling units play a key role in the sizing of the structure and properly sizing the members.

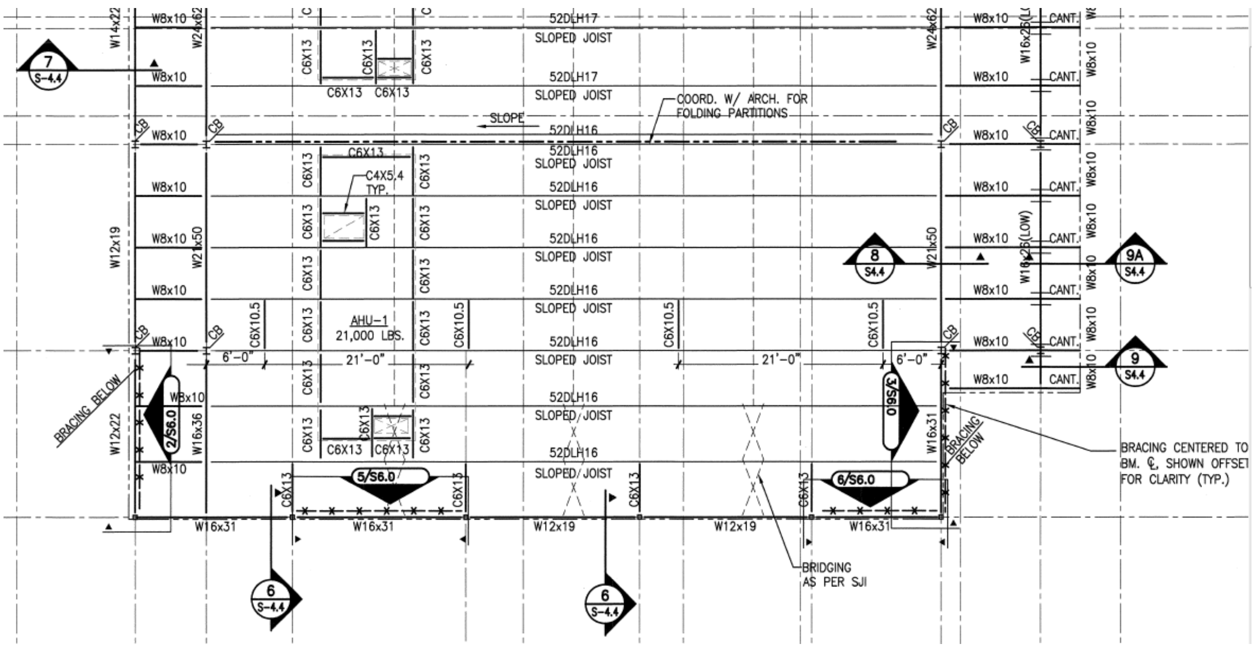


Figure 40: Existing Structure

Spacing

With photovoltaics, spacing is a key component to their effectiveness. Arrays are tilted to optimize collection throughout the year, for this array, the array is set at a 35 degree tilt. The spacing of the array also will determine the loading on each joist. If the spacing is spread out, each joist will carry a lighter load over its tributary area. Through basic solar analysis, the inter-row shading was calculated.

Height = Length of Panel x sin(tilt) = 39.4” x sin(35)= 2.68 ft.

Spacing = Height x cos(azimuth)/tan(altitude)

The altitude and azimuth are based around the lowest solar day of the year at 9 am. The lowest solar day in the northern hemisphere is the winter solstice, December 21st.

December 21st Solar Angles at 9 am:

Altitude: 14.42 degrees

Azimuth: 42.06 degrees

Spacing = 2.68 ft. x cos(42.06)/tan(14.42) = 7.73'

The inter-row shading height of the system is 7.73'. This means the panels will need to be placed 7.73' away from each other to allow for maximum solar collection. The joist spacing is at 5'-9" so panels will be laid out at about every other joist.

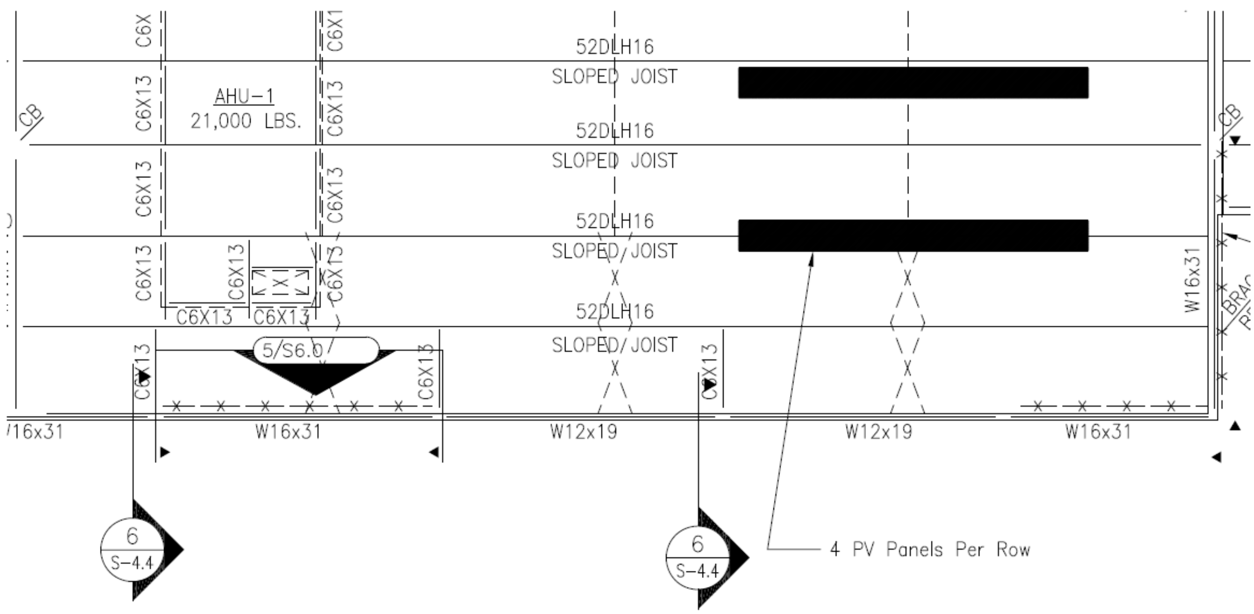


Figure 41: PV Panel Placement

Roof Connection

Photovoltaic in residential settings use J-bolts to tie directly into the structure. With commercial buildings, the system is very different. In the case of West Village Commons, the roof would be considered flat, with only a minor slope to prevent ponding. In addition to ponding, penetrations into the roof membrane can cause leaks and other damage. To properly mount the pv array, a racking system needs to be selected. The specifications for this system include; fix tilt and ballasted. Ballasted racks do not connect directly to the roof. The use of counterweights holds the array in place against wind loads. A ballast racking system was chosen for this breadth. The SolarDock System provides a locally developed product (from Delaware) that will work in this scenario. Benefits of this system also include caged spaces for wiring and controls underneath the panel. This will cut down on roof mounting the conduit for the system and offer weather protection for parts of the system.

Wind Load

A major concern of adding a tilted PV array is the wind load. The because of the slope, pressure difference can build around the panel, causing the panel to be damaged through twisting and lifting. This would not cause any damage or require any extra structure to be added because there is no true connection between the roof and the racking system. The only foreseeable problem with the racking system is that the wind could move the system if strong enough. To check this, ASCE-7 -05 was consulted for the design wind speed chart.

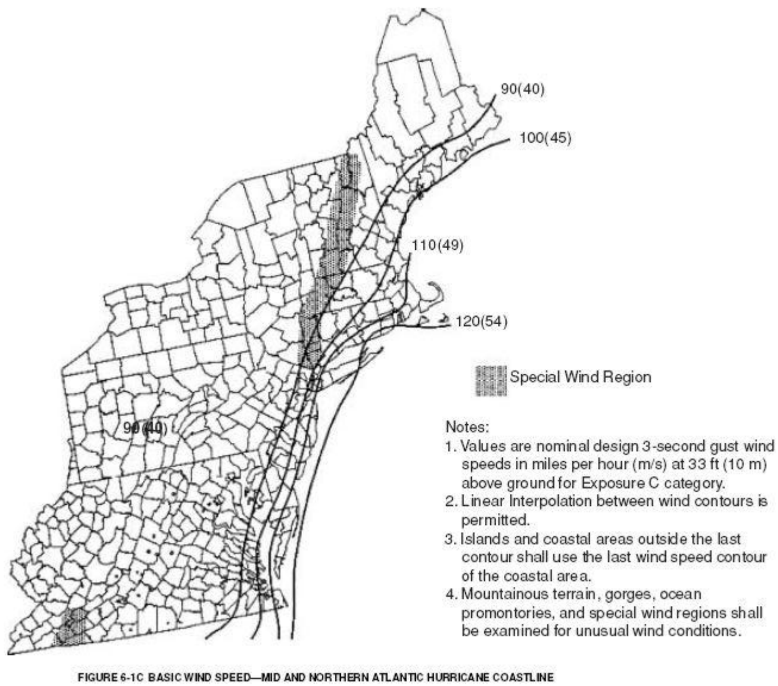


Figure 42: Northeast Wind Data - ASCE 7-05

The wind chart shows a design speed of 90 mph for the Towson, Maryland area. After consulting the manufacturer's product guide, the ballast racking system is designed for wind speeds above 90 mph. While it may be stated in the product brochure, additional contact was made to solar dock to check that the buildings height would not be a problem. While the building is approximately 70' tall, the system is still designed for 90 mph at that height.

Sizing Check

After checking for any wind load design, the last step to analyze the use of this system will be to analyze the impact on the joist. The design data was determined from the structural drawings included in the project. The joist spans 75.58 ft and is spaced at 5' 9". The tributary area is 434.60 ft^2.

Dead Load

- Membrane = 15 psf
- Self-Weight = 10 psf
- Hung MEP = 10 psf
- Total = 35 psf

Snow Load = 30 psf

Additionally the Air Handling Unit needs to be accounted for per truss.

- Weight = 21,000 lbs.
- Area = 294 sq. ft.
- Load = 71.43 psf.
- Width of the AHU along the Joist = 10 ft.

The PV Dead Load must also be accounted for.

- Weight Per Panel = 43 lbs
- Number of panels per joist = 4
- Area of the Panel and Rack = 41.6 sq. ft.
- Length Along Joist = 21.9'
- Load of PVs = 4.14 psf
- Load of Racking = 5 psf

To factor the loads properly, the following equation is used from ASCE 7-05.

$$1.2 \times \text{Dead Load} + 1.6 \times \text{Snow Load} = \text{Factored Load}$$

It will be assumed that the load acts uniformly over the joist for design.

$$1.2 \times (30+71.43+4.14+5) + 1.6 \times 30 = 187 \text{ psf}$$

Over the tributary area

$$187 \text{ psf} \times 434.60 \text{ ft}^2 = 81270.2 \text{ lbs}$$

Because the span is shorter than the clear span conditions, loading must be under the safeload determined in the joist catalog. For a 52DLH16 Joist, the safe load is 82,500 lbs.

$$81{,}270.2 \text{ lbs.} < 82{,}500 \text{ lbs}$$

Summary

The ballasted racking system removes the need for tied connections to the roof or structure. Because of its design, it can easily withstand the wind load for Towson. The system will only act like a dead load on the roof, and from a basic analysis, the current joist in place can hold the array without modification.

Multi-Purpose Room

Lighting Redesign

Space Description

Found on the fourth floor, the multipurpose room, Room 411, spans the South end of the building. The multipurpose room is situated between two corridors that overlook Emerson Drive. On the east side of the building, the glass curtain wall overlooks Emerson drive and the residence halls of West Village. This corridor allows transport directly out of the building through the hillside trail at the south end of the building. The large multipurpose room covers over 8,000 square feet while spanning 76 feet, almost the width of the south end of the building. Considered the largest space in the building, the room can be subdivided into three smaller spaces. Typical functions for the smaller spaces include student organization meetings and occasional lectures. The large space is considered mainly for banquets and large gatherings. Each of the three spaces use architectural elements such as the carpet and ceiling as a way to denote the boundaries of each smaller space, when the dividers are not in use. The ceiling, while primarily acoustical ceiling tile, uses a gypsum frame to "box in" each room. The carpet type changes to reflect ceiling transition on the floor.

Table 11: Multi-Purpose Room Materials

Material	Location	Brand	Product Number	Reflectance
Carpet 6	Floor	Mannington	Dreams, "Formulate"	0.09
Carpet 7	Floor	Mannington	Everywear, "Cambridge"	0.14
Wall 5	Walls	Painted Gypsum (PT-3)	Sherwin Williams SW7537	0.63*
Movable Wall	Walls	Advanced Equipment	Alpha Type S (Match Wall Color)	0.63
Door	Wall	Algoma Hardwoods	Not Specified	0.40*
Ceiling 3	Ceiling	Armstrong	#3909	0.90
Ceiling 5	Ceiling	Painted Gypsum (PT-4)	Sherwin Williams SW7566	0.88*

**Based on comparable color with available product data.*

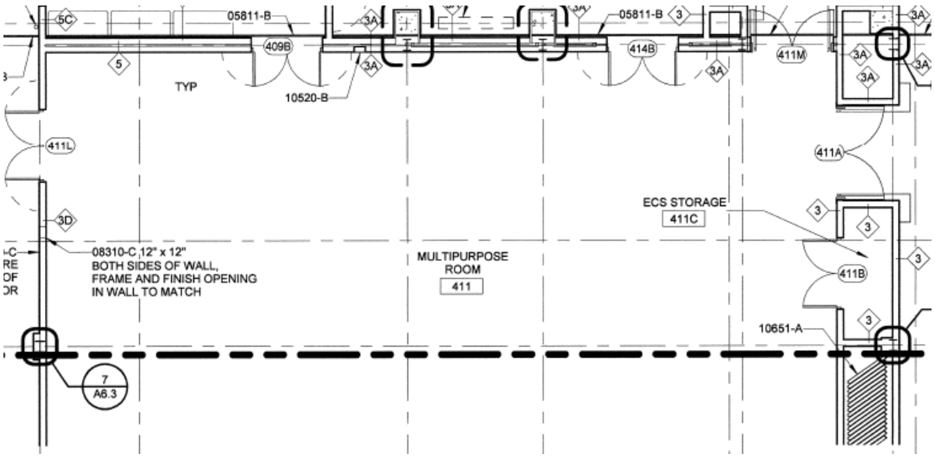


Figure 43: Multipurpose Room Part 1

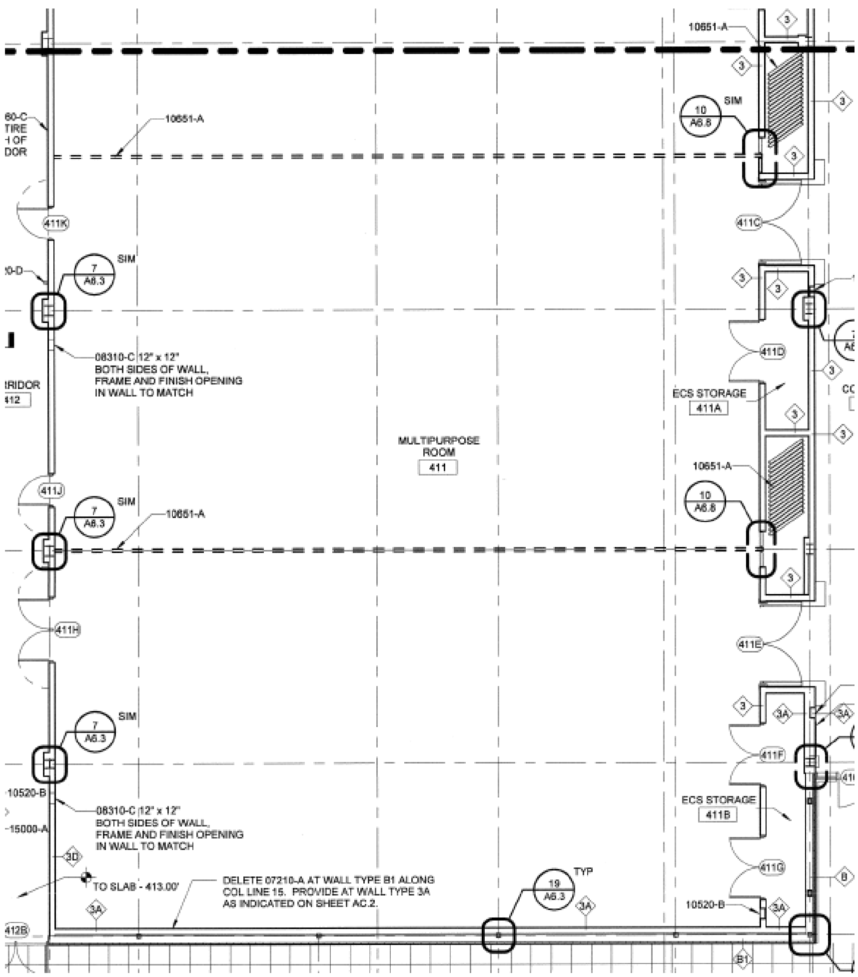


Figure 44: Multipurpose Room Part 2

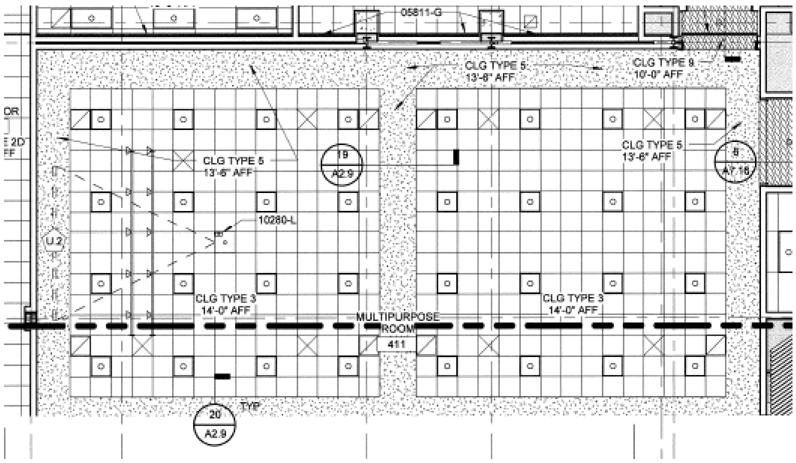


Figure 45: RCP Part 1

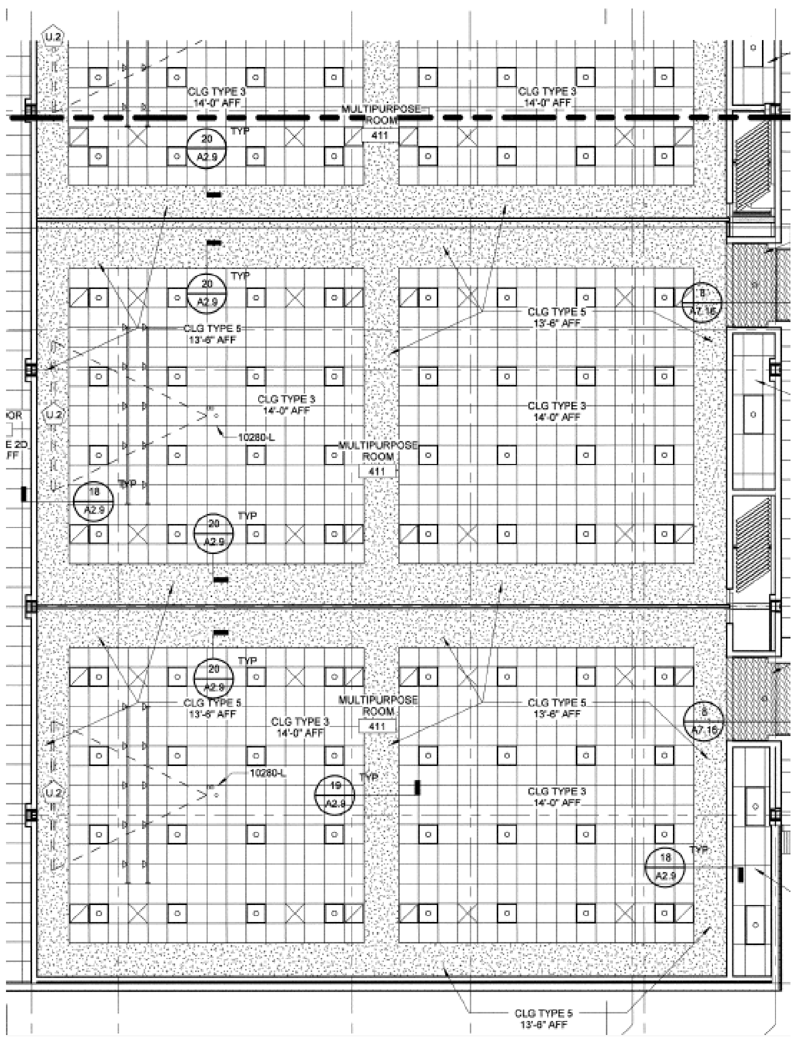


Figure 46: RCP Part 2

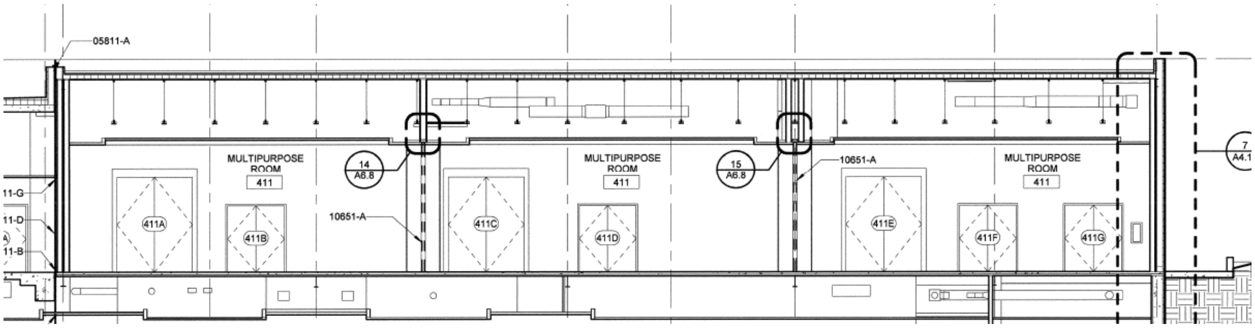
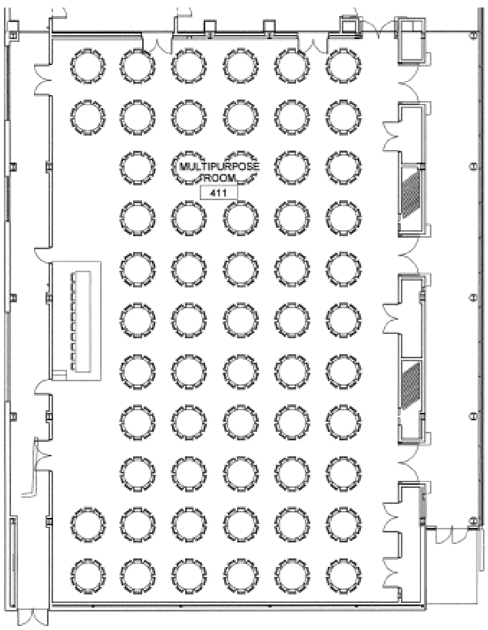
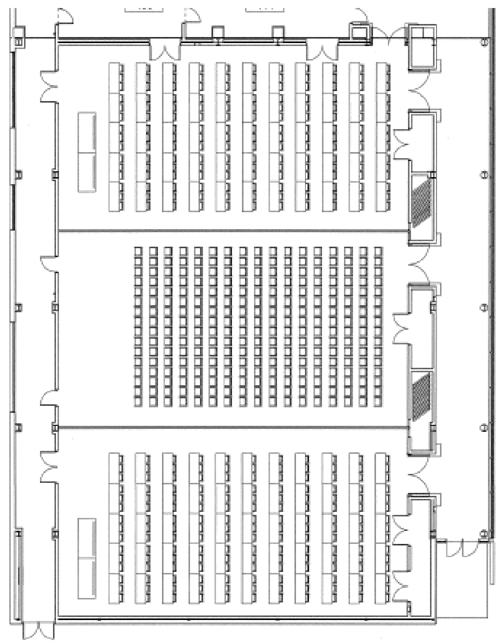


Figure 47: Building Section Facing East



Level 4 - Furniture - Full Banquet	
Description	**Count**
Guest Chair	4
Lounge Chair	22
Sofa - 2 Person	8
5'-8" Diameter Table	59
Dias Table	1
Guest Chair	596

Figure 48: Banquet Setup



Level 4 - Furniture - Divided	
Description	**Count**
Guest Chair	272
Lounge Chair	22
Sofa - 2 Person	8
Guest Chair	330
Seminar Table	110

Figure 49: Typical Divided Setup

Space Function

The multipurpose room serves as a key space for the building. It can be used for lecture, social or dining functions. The space can be used in various forms as individual rooms, combining two rooms, or all three rooms, creating a great hall. This will serve social and banquet functions for students, university faculty or can be rented. Lectures will range from demonstrations to visual presentations made using a projector and screen. Flexibility is of the utmost importance.

Design Criteria

Because of the flexibility of the space, the multipurpose room cannot be classified as simply as some other spaces. Its primary focuses will be on large gatherings for social activities and use as a lecture hall. From these functions, a list of design criteria has been selected. Daylighting will not need to be considered for this room since there are no exterior views/windows.

IESNA Categories: Auditoriums, Ballrooms/Social Events, Educational Lecture Halls

Very Important

1. ***System Control and Flexibility (IESNA)***

   Because of the spaces number one goal of being flexible, the controls must accommodate for the constant change. The space must be able to be controlled as a large space, or each of the individual spaces created by adding the movable partitions. The room can be transformed into one, two, or three separate rooms. The lighting should be controlled at the same spot whether having one large room or three smaller rooms.

2. ***Appearance of Space and Luminaires (IESNA)***

   This space will be used for student functions, but as the newest building on campus, it will be a premiere place to host several faculty and other high end functions. The lighting scheme needs to maintain a high quality and help to promote the space. The space should remain uncluttered and focus on how brilliant the space is rather then the feeling of "Is this really the best place to host a function".

3. ***Color Appearance (IESNA)***

   Whether attending a lecture or a social event, colors should be clear and crisp. It will be important to maintain a warm feeling within the room using a lower CCT to counteract the dull color provided by the carpet and ceiling. CRI > 85, CCT ≤ 3500.

4. ***Modeling Faces or Objects (IESNA)***

   People will be interacting, or focusing their attention on another individual. It is extremely important to provide adequate color rendering capability within the space to reduce phobias of person to person interaction. In any setting whether a lecture or large gathering, there will need to be a central focus and light provided for that. Especially in lectures, a presenter should be modeled well to a person in the front row and the back row. IESNA recommends using an aiming angle between 40 and 60 degrees if using angle adjusted lighting.

5. ***Psychological Effect***

   With the ability to close off the space with movable partitions, it is important to maintain a feeling of spaciousness. While this may not be a huge concern walking into a room for the first time, if the space is divided while occupied, most people will feel the change. It is important to maintain a sense of spaciousness whether in an individual lecture hall or using the entire room for a social event.

6. ***ASHARE 90.1-2007 Power Density:*** 1.3 W/sq. ft.

   Because of the LEED accreditation, it will be important not to exceed the ideal power density in order to apply for reduced energy loads.

Important

1. ***Horizontal Illuminance (IESNA)***
   a. Social Activities: 5 fc
   b. Note Taking (Lectures): 30 fc
   c. Lecture Focal Point: 100 fc
2. ***Vertical Illuminance (IESNA)***
   a. Social Activities: 3 fc
   b. Lecture Focal Point: 50 fc
3. ***Light Distribution on Surfaces (IESNA)***

   Objects in the room should be lit uniformly as to not to distract occupants. Light distribution will reduce the amount of shadows and other visual problems related to non-uniform lighting.
4. ***Luminances of Room Objects***

   Except when using indirect fixtures, higher luminances can draw the eye away from the focal point of the room. By creating relatively low luminance surfaces, glare, distraction and other problems can be easily avoided in the space. A ratio of 3:1 for any surface should not be exceeded.
5. ***Direct Glare (IESNA)***

   Glare can be extremely bothersome and uncomfortable for occupants trying to focus. Luminaires will focus on providing an ambient light rather than targeting any one object. Through the use of targeting, light targeted specifically for presenters or demonstrations will be avoided. General angle measure will range between 40 and 60 degrees.
6. ***Reflected Glare (IESNA)***

   Because of the typical matte/flat finish of the walls, along with the use of carpet, any reflected glare is minimized and should not be present within the room.
7. ***Flicker (IESNA)***

   The use of electronic dimming ballasts removes flicker as a concern for the space. Interior lighting will be fluorescent lighting.
8. ***Source/Task/Eye Geometry (IESNA)***

   Due to the nature of a flat room, the luminaires should not hang in view or cause any distraction from the speaker. To achieve this, a luminaire recessed in the ceiling will adequately handle this requirement. It is important that a person can look down to take notes and then look up and have no problem transitioning to following a demonstration or presentation.

9. ***Maintenance***

   While being considered one of the premiere spaces in the building, it is important to maintain the space. Since the ceiling is only at 12'-0" typically, a ladder will be able to access lamps easily.

Design Overview

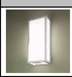
Concept

Covering 8,000 square feet, the multi-purpose space is the single largest space within the building. Designed to host a range of functions from banquets to lectures, the space must be both elegant and practical. The lighting concept is to focus on the clear defined edges of the space through the use of square and rectangular based fixtures. Both lecture and social scenes develop from a need for ambient lighting. Social settings will then add a layer of decorative lighting while, during lectures, a layer of task lighting will be added to the space. Additionally in the lecture scheme, it will be important to highlight the presenter during more traditional lectures. Luminance ratios will factor into the control schematic between a traditional lecture/demonstration and the digitally based presentation.

Luminaire/Lamp Selection

The multipurpose room is a premiere space for the building and the university. To promote the sustainability of the building, the spaces fluorescent and compact fluorescent lamps were selected to provide adequate lighting. With choosing fluorescent and compact fluorescent light sources, dimming within the spaces can be achieved. Because the spaces uses, banquet and lecture, 3000K lamps were used to promote a warmer feel within the space. Accent and decorative lighting work to draw attention to the space during its various functions. For speakers and lectures, ceramic metal halides with a CRI of above 90 are selected to model the presenter and any demonstrations with excellent color.

Fixture Schedule

Luminaire		Classification	Mounting	Lamp		Ballast	Voltage	Watts	Description	Fixture
M1		4'-0" Indirect Fluorescent Concealed Cove Light	13'-0" within cove. See Detail.	GE F32T8/SPX30/ECO	3000K, CRI = 86	Lutron EC5 T832 J UNV 1	277	32	One piece 20 gauge steel 4 ft housing. T8 lamping. Semi specular reflector with high white reflectance finish. 277V dimmable electronic ballast.	Focal Point FCVA-26-1T8-1C-D-CV-HW-4
M2		6.75" x 6.75" Recessed CFL Downlight	Ceiling Recessed at 14'-0" A.F.F	GE F32TBX/830/A/ECO	3000K, CRI = 82	Lutron EC3D T4MW K U 1	277	27	One piece die-cast 6.75" square frame. Trim to provide 25 degree cutoff from view of lamp. Painted white flange finish. 277 V with electronic ballast.	Focal Point Housing : FC66-32TT-S-277-SO-T-D66 Trim: D66-SO-DN-WH
M3		30" x 30" x 10" Direct/Indirect CFL Pendant	Pendant Mounted 11'-6" A.F.F.	GE F26DBX/830/ECO4P	3000K, CRI = 82	Advance VEZ-2Q26-M2-LD	277	54	30" x 30" x 10" box pendant with opal acrylic panels. Brushed aluminum finished frame. Provide (2) 2 - lamp electronic diming ballast at 277 V	Winona Lighting 5830-30-FM-277V-OA-BAL-STD
M4		7.6" Recessed, Adjustable Ceramic Metal Halide Downlight	Ceiling Recessed at 14'-0" A.F.F	Philips CDM-TC 35W/930	3000K, CRI > 90	Advance IMH-39-G-277	277	45	Die cast adjustable downlighting with integral reflector. Adjusts 55 degree vertical angle. 360 degree horizontal angle adjustment. 15 degree reflector. Powder coated white finish. 277V with electronic ballast	RSA Lighting Housing: CDM6NCMH-39-277 Holder: CDMA-T4-WH-15-39
M5		4" X 8" X 18" Wall Sconce	Mounted at 7'-6" Above Finished Floor	GE F27BXSPX30RS 10PK	3000K, CRI = 82	GE B224PUNV-COG1C	277	27	4" x 8" x 18" wall sconce with opal acrylic panels. Brushed aluminum frame. Coordinate with Fixture M3.	Winona Lighting 5833-F-277V-OA-BAL-STD

Light Loss Factors

Table 12: Multi-Purpose Light Loss Factors

Luminaire	LLD	LDD	Ballast Factor	Total LLF
M1	0.95	0.92	0.85	0.74
M2	0.85	0.92	1.00	0.78
M3	0.85	0.92	1.00	0.78
M4	0.81	0.92	1.00	0.75
M5	0.90	0.92	1.02	0.85

Mounting Detail

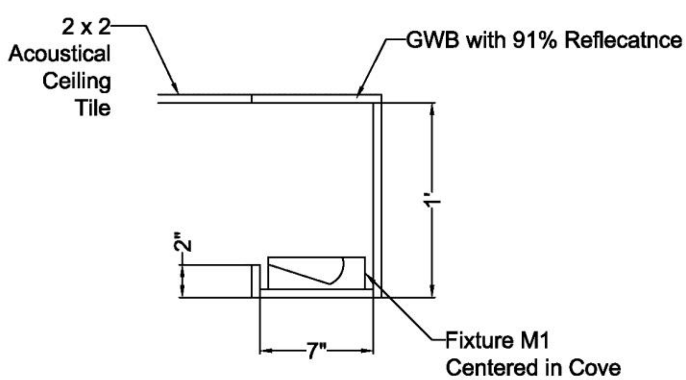


Figure 50: Cove Fixture Mounting Detail

Design Performance

Criteria Evaluation

The lighting design incorporates flexibility and function as its primary basis of design. The space uses accent lighting and decorative lighting while adding layers of light when needed throughout the room. The rectangular downlights, box pendants and cove lighting help to show form within the space. As lectures can range from power point presentations to guest speakers with demonstrations, the flexibility of the cove lighting, the downlights and spotlights provides for the variety of lectures. During the banquet setting, the cove lighting and decorative pendants will be the primary source of light into the space. Through controls the downlights and spotlights can be added to provide additional light when needed. To control the amount of light in the space, the cove and pendants can be dimmed to provide less light and become a more aesthetic only feature.

The flexibility of design allows for various light levels to be created within the space. Either the cove or pendants can provide 10 fc of light, enough to meet dining recommendations. The cove lighting can be dimmed to provide low light levels during projector based lectures. Downlights bring the overall light level up to 27 fc when required. The additional spotlights can provide an additional 30 to 70 fc depending on the number of rows required. Each of the three lecture areas are designed identically.

Social/ Dining: 11 fc

Lecture with downlights: 27 fc

Front of Room for Lecture: 90 fc average

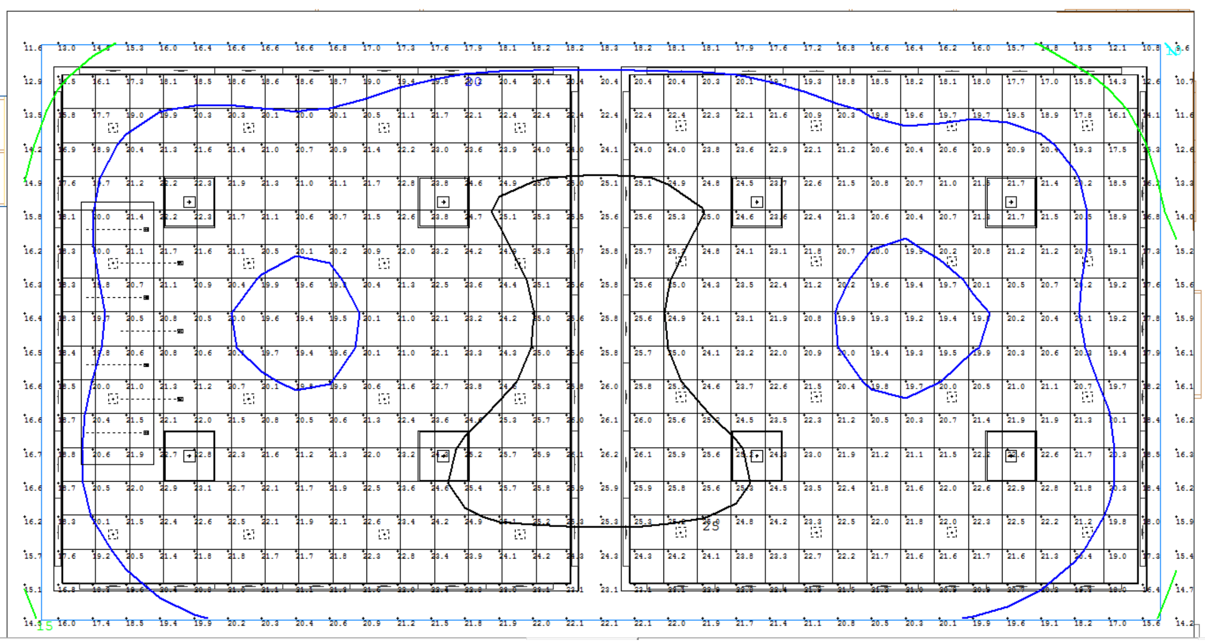


Figure 51: Banquet Mode

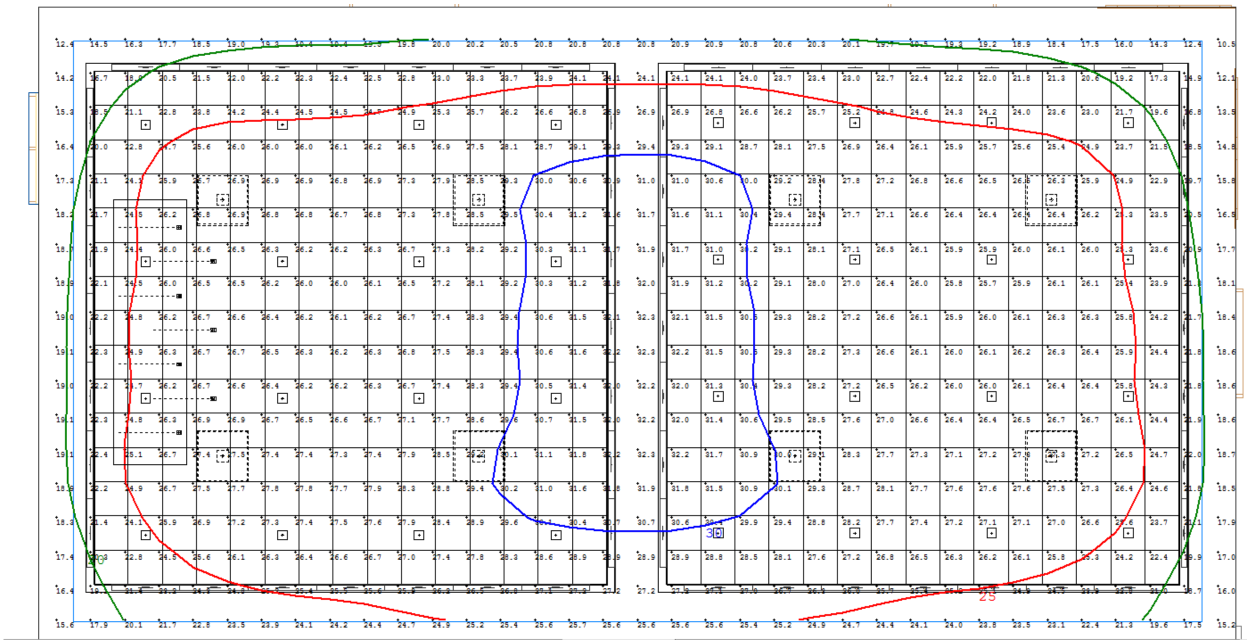


Figure 52: Lecture Mode

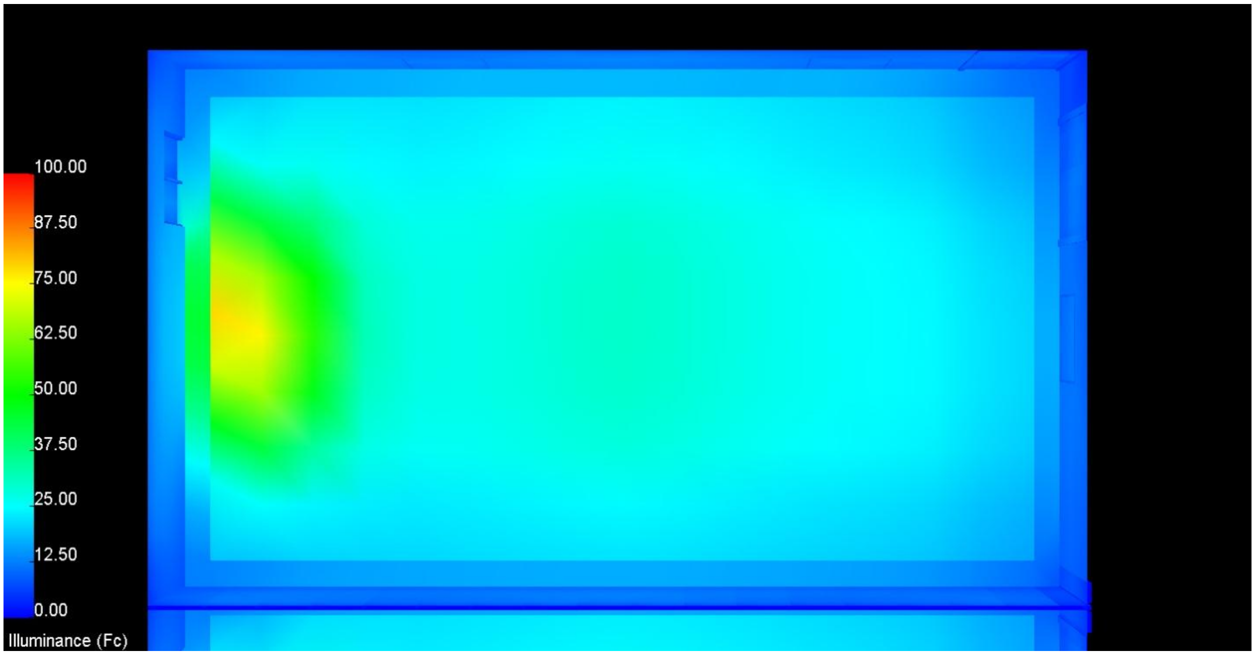


Figure 53: Psuedo-Rendering of Lecture Mode with Spotlights

Lighting Power Density

The lighting power density in the space is 1.65 W/sq ft. Because of the decorative pendants and sconces that only provide decorative lighting to the space, the power density allowance can be increased from 1.3 W/ sq. ft. to 2.3 W/sq. ft.

Table 13: Multi-Purpose Room LPD

Luminaire	*Quantity*	*Watts(W)*	*Required Power (W)*
M1	168	31.6	5309
M2	24	102	2448
M3	96	42	4032
M4	21	45	945
M5	18	24	432
		Total Power	13166 W
		Square Foot	8000
		LPD	1.65 W/sqft
		ASHRAE	2.3 W/sqft

Renderings

Figure 54: Lecture Space Rendering

Figure 55: Social Setting Rendering

Controls

The multipurpose space will utilize Ecosystem controls with the Grafik Eye interface. With partition sensors, each control pad will be able to control the entire room or only a certain room, based on partition location.

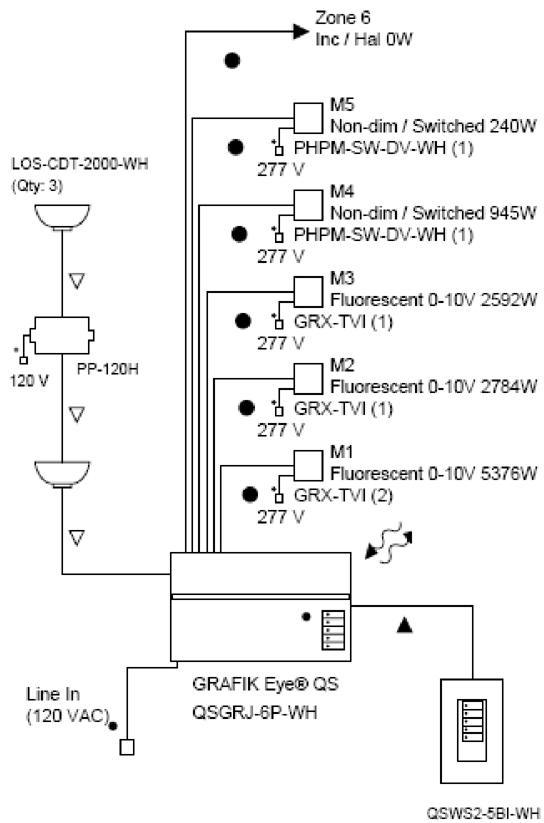


Figure 56: Grafik Eye Control System

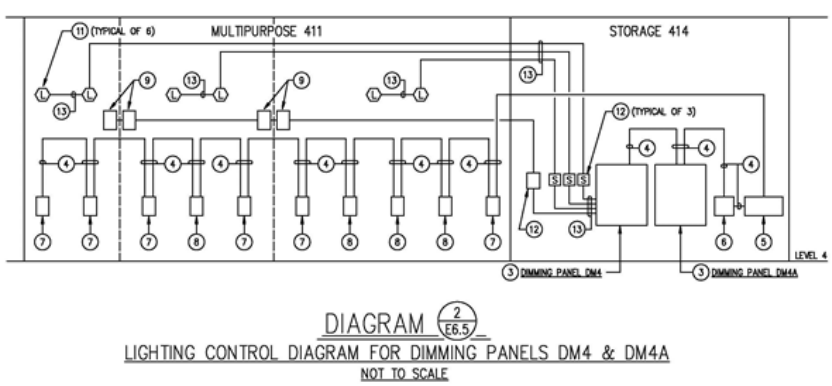
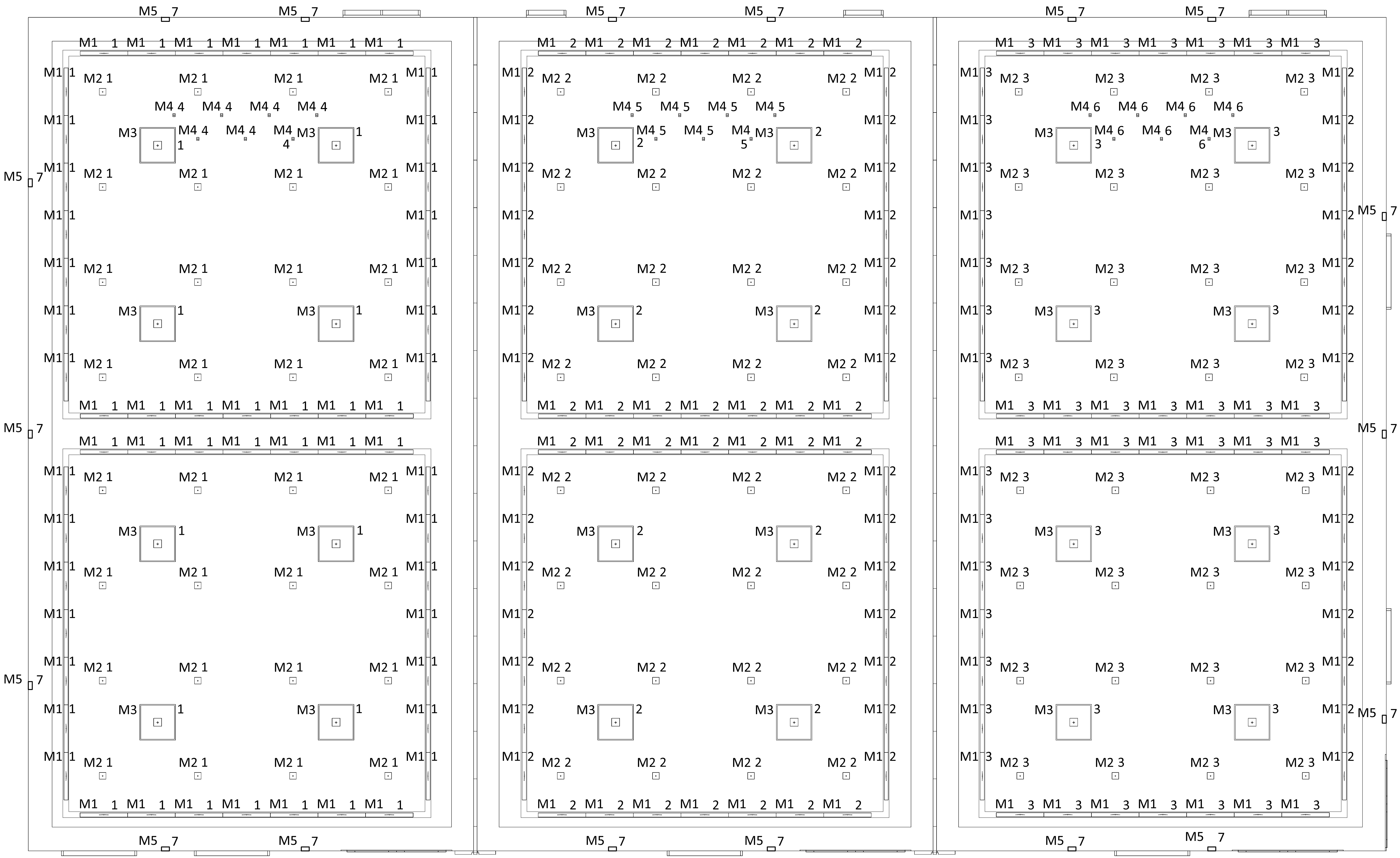


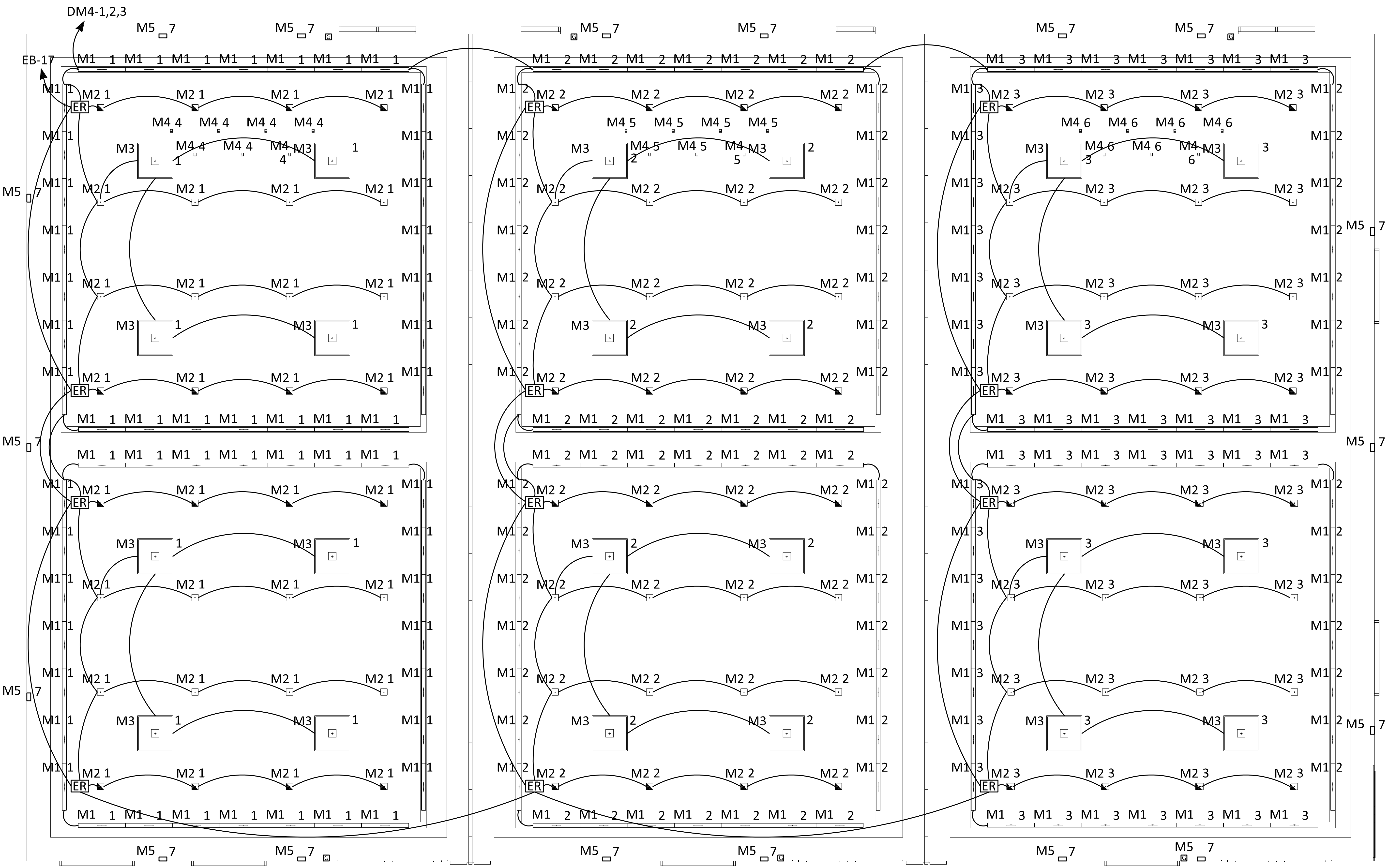
Figure 57: system Overview with Partition Sensors

Table 14: Multi-Purpose Space Controls

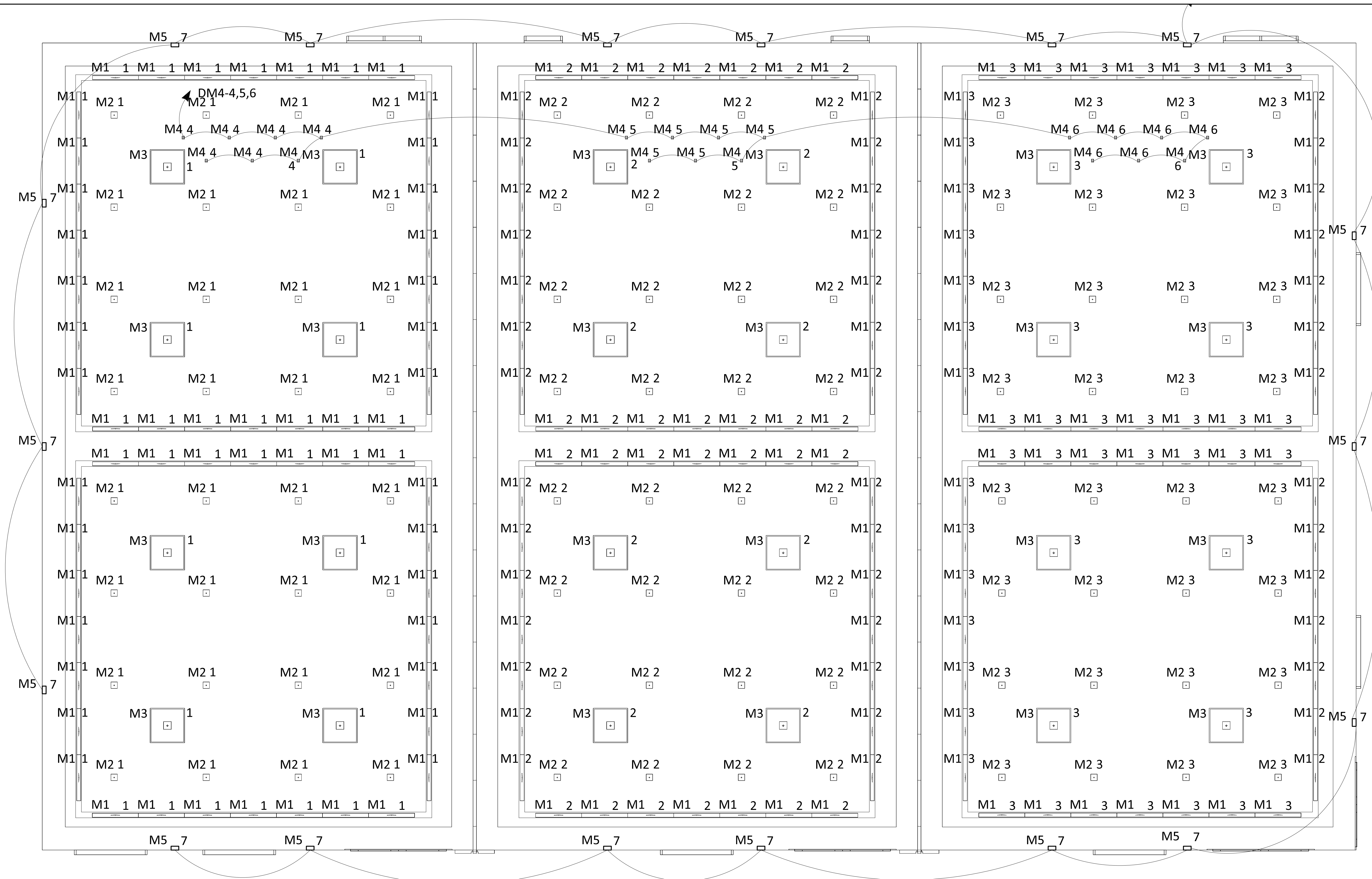
Tag	*Manufacturer*	*Catalog Number*	*Description*
G	Lutron	Grafik Eye QS	Multiple Scene wireless lighting control unit. Integrate with dimming panel DM4. Provide wireless control stations where needed.



E1.3	MULTIPURPOSE ROOM LIGHTING LAYOUT	
	SCALE: $\frac{1}{8}$" = 1'-0"	AE 497G/882
	PATRICK MORGAN	APRIL 7, 2011



E2.3A	MULTIPURPOSE ROOM POWER PLAN	
	SCALE: $\frac{1}{8}$" = 1'-0"	AE 497G/882
	PATRICK MORGAN	APRIL 7, 2011



E2.3B	MULTIPURPOSE ROOM POWER PLAN	
	SCALE: $\frac{1}{8}$" = 1'-0"	AE 497G/882
	PATRICK MORGAN	APRIL 7, 2011

Roof Terrace

Lighting Redesign

Space Description

A common trend in new buildings is the use of green roofs. They have many benefits from drainage to reducing heat island effect. A new trend is to use these green spaces as spaces for the public to enjoy. Located on the third floor, the roof garden is a beautiful space for which any of the build occupants can enjoy. A path paved of stone runs through the garden leading to individual benches. While standing outside, the glass façade of the building shows a transparency of the building extending inward to outward. The glazing changes types from clear to frit to finally a translucent glass. Found on the east side of the building, the 40' by 100' space offers an interesting place to study while enjoying the outdoors. A parapet extends around the roof 3'-4", helping to frame the space while still allowing for great views back towards the campus.

Table 15: Material Properties

Material	Location	Brand	Product Number	Reflectance
Grass	Roof Covering	Local Manufacturer	Local Supplier	0.14
Stone	Pathway	Noce Tavertine	Local Supplier	0.16
Brick	Parapet	Local Manufacturer	Local Supplier	0.22
Aluminum	Window Frame	Local Manufacturer	Local Supplier	0.60

Table 16: Glazing Properties

Glazing	Type	SHGC	Transmittance	Reflectance
GL-5	Frit	0.30	44%	22%

Figure 58: Rendering of Green Roof, Courtesy GWWO.

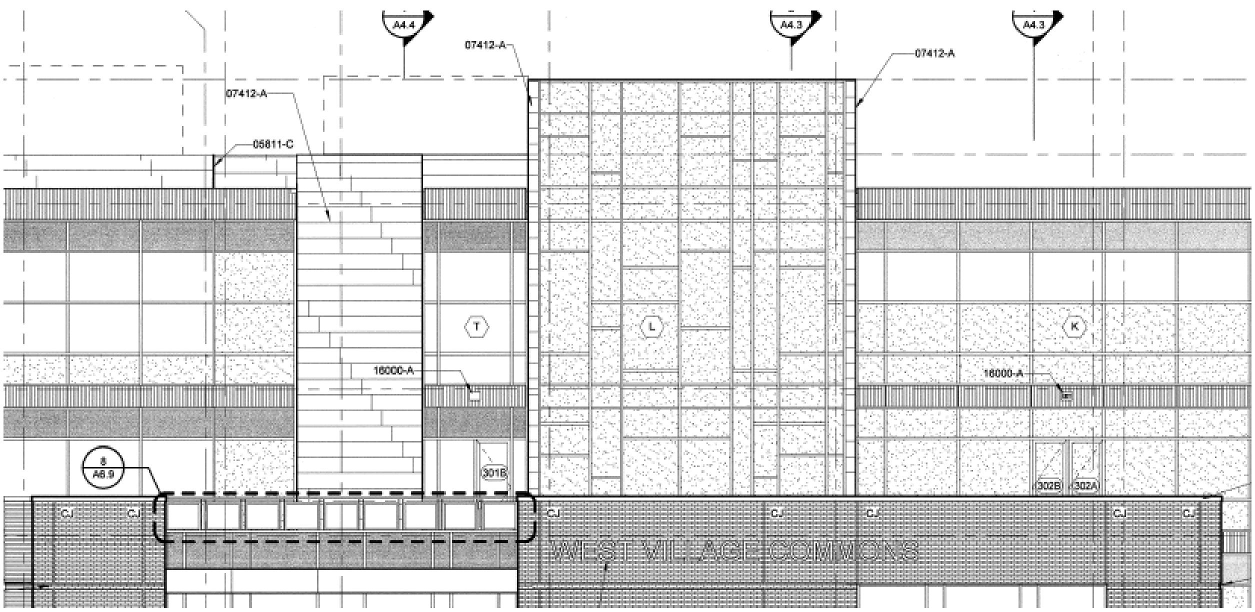


Figure 59: East Façade

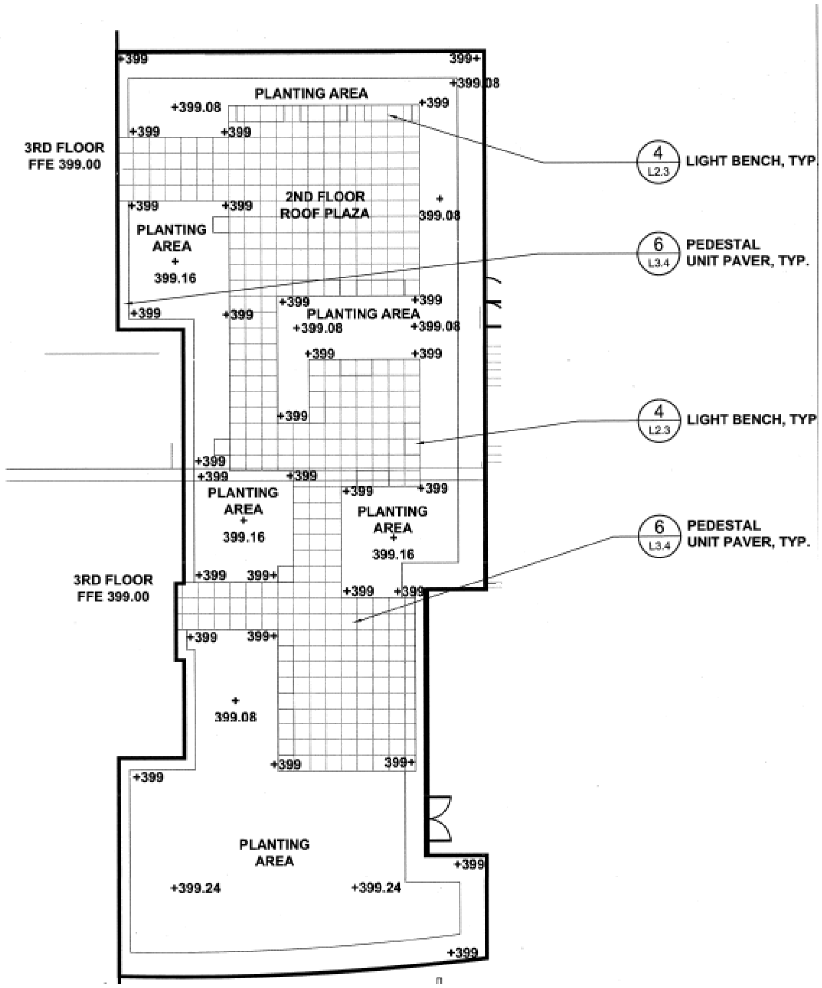


Figure 60: Hardscape Plan

Space Function

Incorporated into the third floor, the roof terrace serves as an isolated green space primarily for students. With nice weather, this is an ideal place to enjoy during the day. During the evening and special events, the study lounge's balcony area serves as the pre-function area for the multi-purpose room. The terrace, with is connection to the first level of the lounge, will serve as an outdoor pre-function area when the multi-purpose room is in use. Because of its overall size and views, special events can also be held in the terrace. During the evening, this will be a purely decorative space.

Design Criteria

The garden space on the roof of the second floor is designed as an outdoor enjoyable environment that promotes studying and relaxation.

IESNA Categories: Garden Terrace

Very Important

1. ***Appearance of Space and Luminaires (IESNA)***

   Carrying the title of signature space for the building, the roof garden will need to stand out in its appearance. Not only will the greenery, façade and pathways need to be maintained, the lighting should be integral to its appearance. Luminaires should not protrude awkwardly into the space. Each decision made should reflect the overall importance of the roof garden to both students and the university.

2. ***Direct Glare (IESNA)***

   Direct glare is uncomfortable in any indoor or outdoor environment. Because of the limited mounting capabilities, some uplight fixtures, if not aimed properly, cause glare that can be blinding. At the same time, no fixture should take away from the surrounding scenery and night sky.

3. ***Light Distribution on Surfaces (IESNA)***

   While uniformity is essential for indoor environments, lighting can accent the rough edge of nature or of the building. The brick around the perimeter, individual blades of grass and stone pathways all have unique textures which benefit and add character to the space when non-uniform lighting techniques are employed.

4. ***Modeling of Faces or Objects (IESNA)***

   As a gathering space, a person interacting is a primary focus of the lighting design. It is also important to render the entire outdoor scene well, so that memories of the space are vivid and memorable.

5. ***ASHARE 90.1-2007 Power Density:*** 0.2 W/sq. ft.

   Because of the LEED accreditation, it will be important not to exceed the ideal power density in order to apply for reduced energy loads.

Important

1. ***Color Appearance and Contrast (IESNA)***

   Distinguishing between colors takes precedence in an outdoor space. Being able to highlight both the red within brick and the green within a grass can make for dramatic scenes. A high CRI, CRI > 85 will need to be used to have accurate color clarity. If LEDs are used, it will be important to note the performance of the LED when rendering red. CCT can vary especially when trying to achieve a certain color effect between the lighting and the surface.

2. ***Light Pollution/Trespass (IESNA)***

   As a LEED accredited space, light pollution must be reduced, if not eliminated. Some reflected light will escape into the sky, but all luminaires will need to be of full cutoff, or at least directed so no light is directly escaping into the sky.

3. Point(s) of Interest (IESNA)

As a focal point of the university, highlighted elements should be carefully chosen. Not only can this be seen from within the space, but also through the glass façade. The entire garden roof must serve as a point of interest.

4. Shadows (IESNA)

Primarily a safety concern, shadows must be reduced on the pathway so that no one trips over any loose or rough pavers. Shadows can also be used to add dramatic effect to the scene and intertwine with some of the unique outdoor textures.

5. Surface Characteristics (IESNA)

As noted above in several instances, the textures of outdoor surfaces can create unique environments. It will be important to study various techniques and decide how to accurately highlight each texture and how it will be exposed to artificial light.

6. Maintenance (IESNA)

While the luminaires may not be hard to access, the luminaires will need to handle weather conditions, ranging from heavy rain to heavy snow. Luminaires will need to be sealed along with having easy access to replace burnt out lamps.

Design Overview

Concept

Used primarily during the day, the Terrace offers a unique space to occupy at night. This green roof connects the students and visitors of the lounge to the outdoor environment. To utilize the full purpose of this space, the covering on the green roof remains as typical grasses, so that during the day, students can enjoy the grass. At night, the lighting will preserve the grass and create a boundary between the stone pathway and grass. Additionally, there are three main view points along the perimeter of the space. One focuses on the quad, and two that give various perspectives on the preserved oak tree. All spots will be able to look out over student residence halls and the rest of the University. To integrate the sustainable aspect of the building, the lighting will be low wattage or self-sustaining. This will truly focus on the “green” aspect of the space.

Lamp/Luminaire Selection

Because of trying to concept both lamp life and power consumption, integrated LEDs will provide the best lighting within the space. As the space is only lit during the night, color temperature will not be as much of a concern. The railing lighting will want to focus on rendering brick well; otherwise the lighting will focus on the grass or stone. Both respond well to LED lighting. Because of the minimal architectural elements within the space, luminaires that can be recessed or hidded will help to highlight the key points.

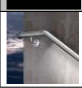
Light Loss Factors

With using LEDs, lamp lumen depreciation assumed at 0.8 based on AE 561 coursework.

	BF	LLD	LDD	Total
T1	1	0.8	0.8	0.64
T2	1	0.8	0.8	0.64
T3	1	0.8	0.8	0.64

Figure 61: Terrace LLF

Fixture Schedule

Luminaire		Classification	Mounting	Lamp		Ballast	Voltage	Watts	Description	Fixture
T1		2'-0" Direct Surface Mounted LED Strip	Surface Underside of Bench	Integrated LED	119 lms/ ft 3500K	Winona TW-T300 Transformer	277	9	Surface Mounted LED Strip Light. Wet Location IP66 Rated. 24VAC input. Fixed mounting with recessed bottom feed.	Winona Lighting WSL-203W-B2-110-35K-ND24V-F-STD
T2		6" x 6" In-Grade LED Paver	In-Grade	Integrated LED	10 lms	N/A	N/A	N/A	In-Grade LED Paver with included photovoltaic. 6 hour charge time. IP 68 Outdoor Rating, Brushed Stainless Steel Finish. Include housing and anchor plate.	Meteor Lighting SH-170C-W-B-H
T3		60" Railing with Direct Downlight	Wall Mounted at 3'-0" Above Grade	Integrated LED	48 lms/ft 2700K	Included 200W Driver DR200AM	277	200	5' Wall Mounted Aluminum Railing with integrated LEDs. LEDs at 2700K. 200W Outdoor Rated Driver.	io Lighting 0-06-SSS-2-WM-NR-10-27K-GB5-277V

Mounting Details

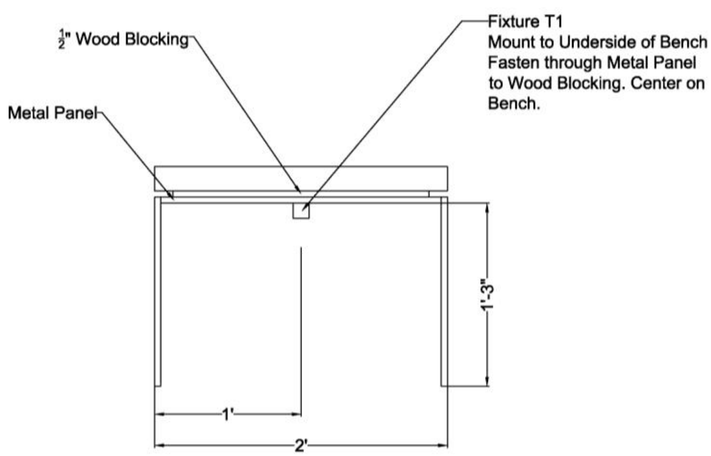


Figure 62: Under Bench Lighting Detail

Design Performance

Criteria Evaluation

The terrace space was designed without an illuminance criterion to capture the effect of the decorative space. Since the adjacent façade is nearly 100% glass, the space will receive an ambient contribution from the building. Along the center of the façade is a stairwell that is illuminated continuously. The most important criterion of the space is the appearance of the space. Because the space is made up of grass areas and a stone pathway, the points of interest will be any objects within the space. Through under bench lighting, the seating areas are defined. Through in-grade lighting, the pathway is defined. The lighting fixtures within the space are hidden so that nothing protrudes into the space. The space's focus turns to the areas looking out over the campus. With integrated railing LEDs, the texture of the brick is grazed, giving a feeling of confinement within the space, while being in an outdoor environment. Railing lighting also draws attention to the key viewing spots of Towson University and the rest of West Village. The railing and under bench lighting are both LEDs symbolizing the desire of the building to be sustainable. The integrated photovoltaic LEDs help define the space and reinforce the sustainability concept. There will be direct uplight from the in-grade fixtures, but the overall output is only 10 lumens. This will add a nice glowing element to the path, but will not cause any problems with sky glow.

Lighting Power Density

The in-grade pavers were not added into the power density requirement because they do require connection to the buildings power supply. The only light required in the space would be the under bench lighting. The railing lighting is a decorative addition. Because of the spaces importance, it is ideal to have a more decorative lighting design. The terrace space is included as a tradable watts space. Because of the reduced power density in the study lounge, the 0.07 W/sq. ft. overage of the terrace can be added into the study lounge.

Table 17: Terrace Lighting Power Density

Luminaire	*Quantity*	*Watts(W)*	*Required Power (W)*
T1	16	68	288
T3	7	20	145
		Total Power	433
		Square Foot	1604
		LPD	0.27 W/sq ft
		ASHRAE	0.2 W/sq ft

Renderings

Figure 63: View from above of Terrace Lighting

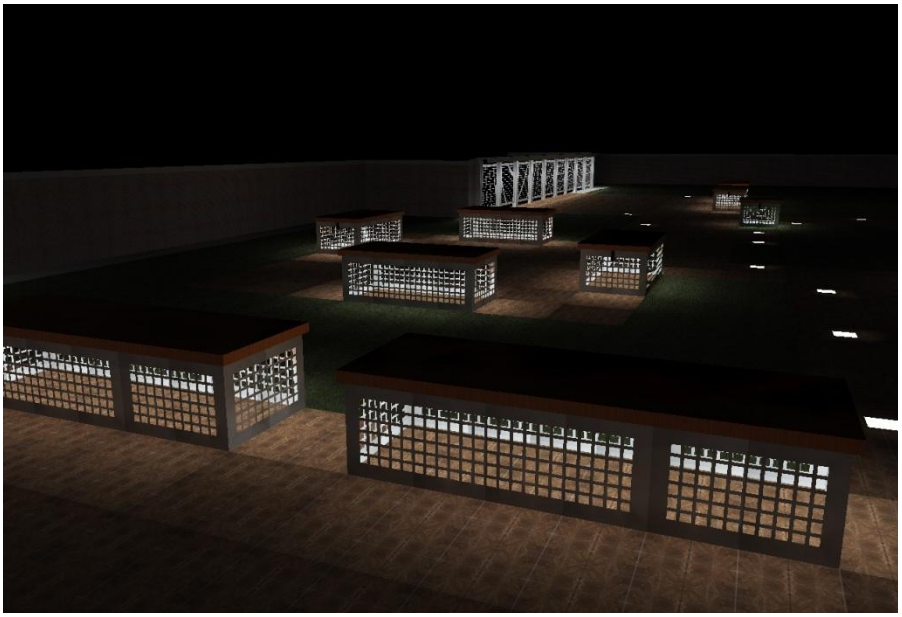
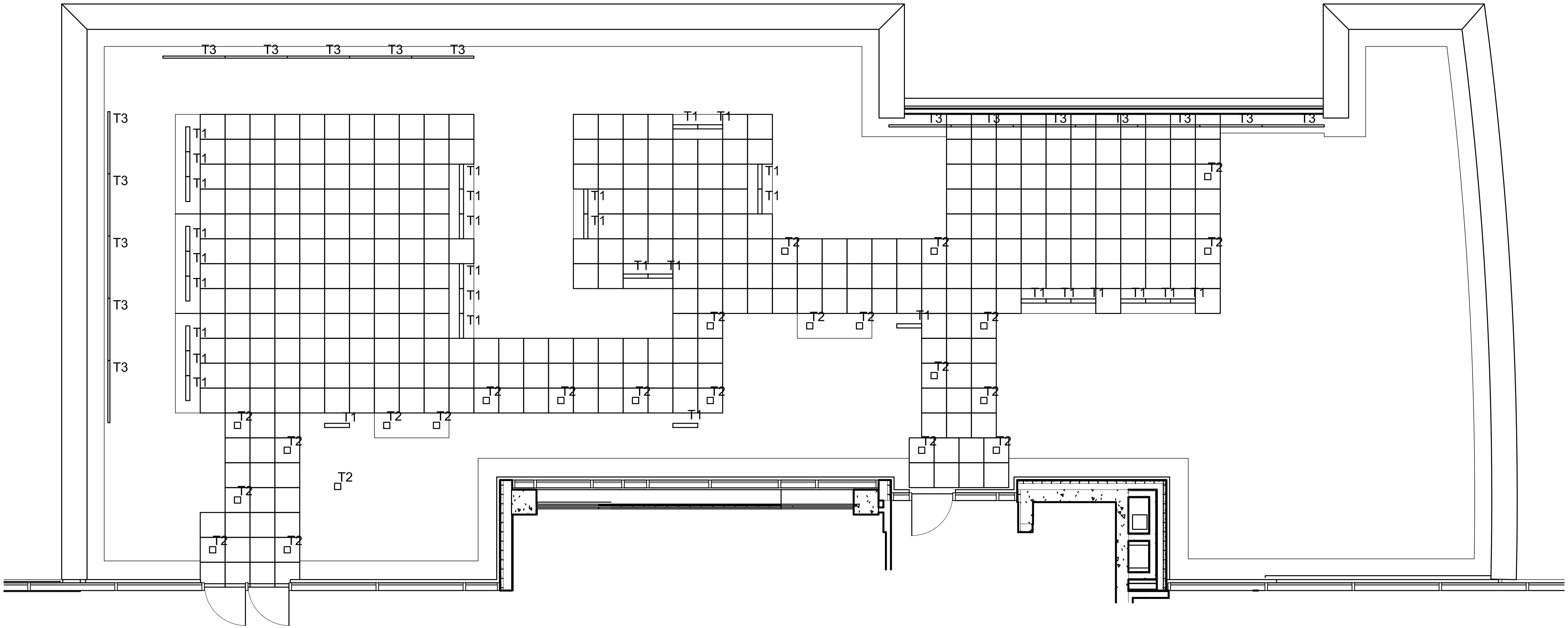


Figure 64: Under Bench lighting

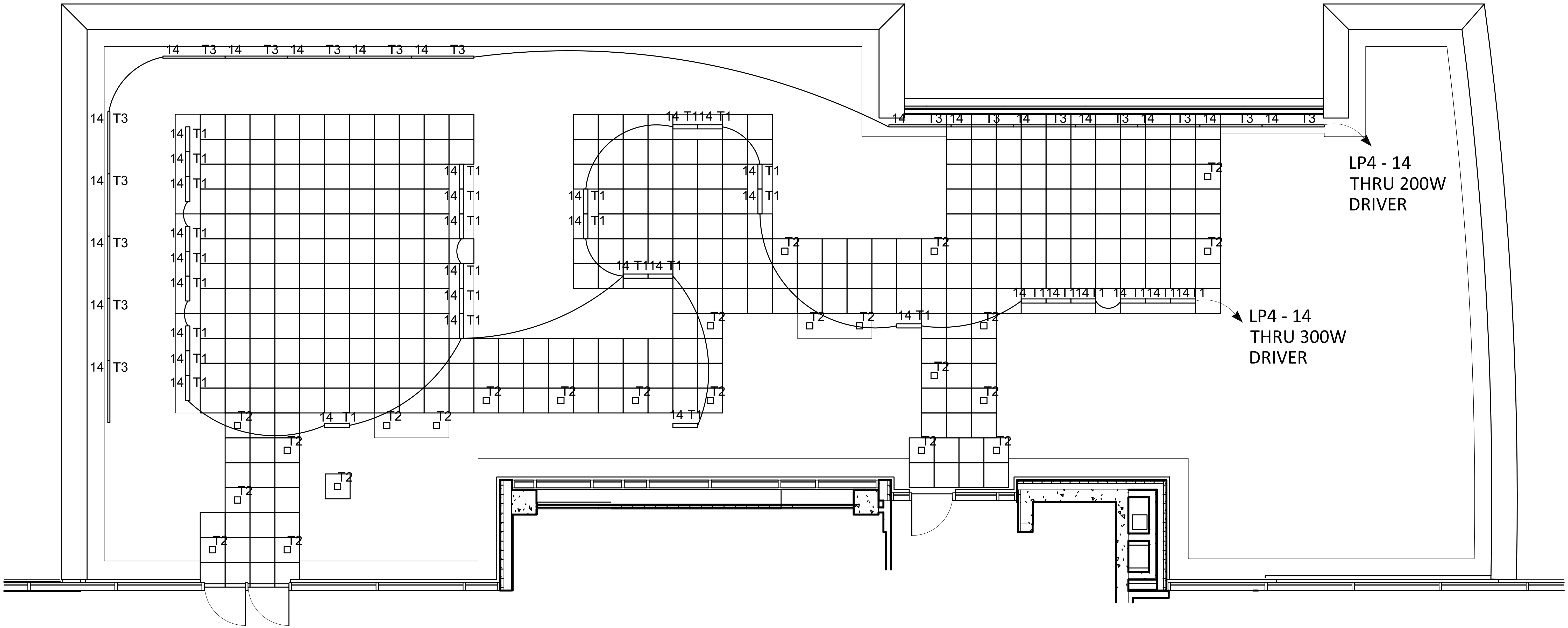
Figure 65: Perimeter Wall Grazing, Point of Interest

Controls

All exterior lighting for the space will be done through the building automation system. In-grade lighting with integrated photovoltaics will use a built in photosensor for control. The emergency lighting for the space will use exit signs equipped with LED lighting heads and replace the existing exit signs.



E1.4	TERRACE LIGHTING PLAN	
	SCALE: $\frac{1}{8}$" = 1'-0"	AE 497G/882
	PATRICK MORGAN	APRIL 7, 2011



NOTES

1. DRIVERS TO BE MOUNTED IN ECS STORAGE 311 TO PREVENT VOLTAGE DROP.

E2.4	TERRACE POWER PLAN	
	SCALE: $\frac{1}{8}$" = 1'-0"	AE 497G/882
	PATRICK MORGAN	APRIL 7, 2011

Study Lounge

Lighting Redesign

Space Description

Located on the third floor, the study lounge overlooks the Village Quad. Whether being able to enjoy the views of the quad or focus on work at hand, students have a multi-level lounge to enjoy their time inside. The multi-level space replicates the grand stair found downstairs along with several of the textures. The brick and wood combined with the clear northern glass ties the indoor and outdoor environment while being covered by the "cloud" ceiling. To the east and west translucent and fritted glass help to control morning and late day sun. The study lounge works to provide a grand and open environment for students to come and enjoy the space. Through the third floor corridor, the garden roof can be quickly accessed. With the glass, high ceilings, and easy transition to the outdoors, this space is one of the most open and transitional spaces within the building.

Table 18: Study Lounge Materials

Material	Location	Brand	Product Number	Reflectance
Stone	Floor	Noce Tavertine	Local Supplier	0.16
Carpet 4	Floor	Mannington	Deep Thoughts, "Formulate"	0.03
Wood 1	Walls	Eucalyptus Wood	Local Supplier	0.27
Wall 4	Walls	Painted Gypsum (PT-3)	Sherwin Williams SW7537	0.63*
Ceiling 7	Ceiling	Armstrong	#3906	0.90
Exposed Ceiling	Ceiling	Paint (PT-2)	Sherwin Williams SW7076	0.88

Table 19: Glazing Properties

Glazing	Type	SHGC	Transmittance	Reflectance
Railing	Clear	N/A	84%	8%
GL-3	Clear	0.38	70%	11%
GL-4	Translucent	0.37	60%	12%
GL-5	Frit	0.30	44%	22%

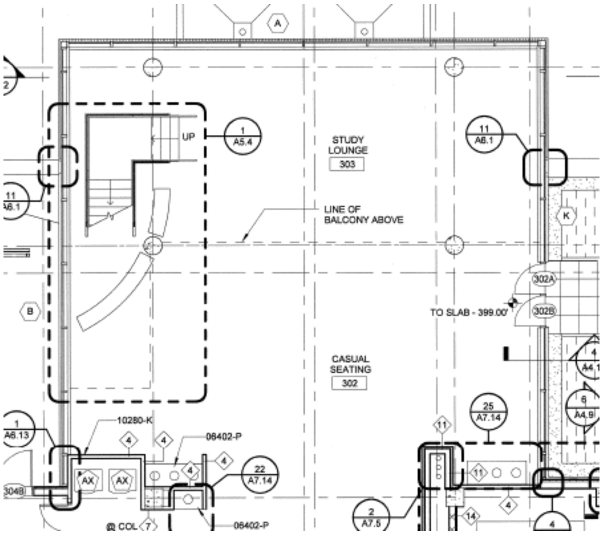


Figure 66: Third Floor Plan

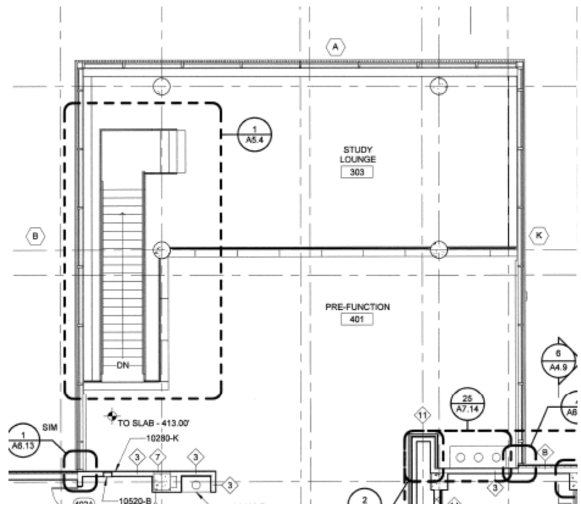


Figure 67: Fourth Floor Plan

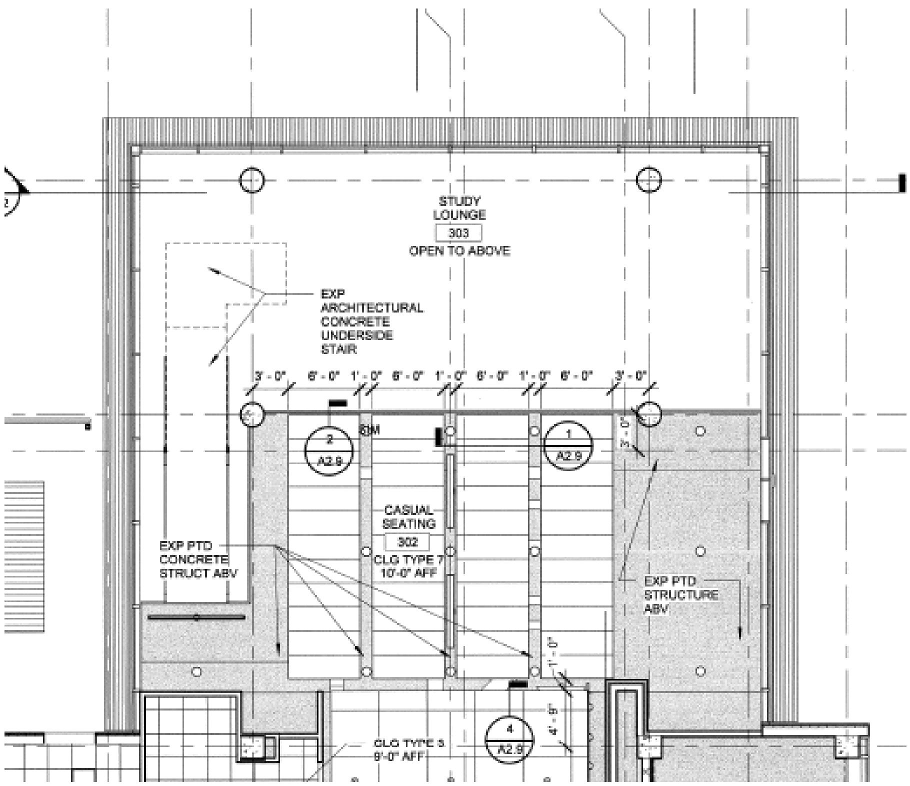


Figure 68: RCP Third Floor

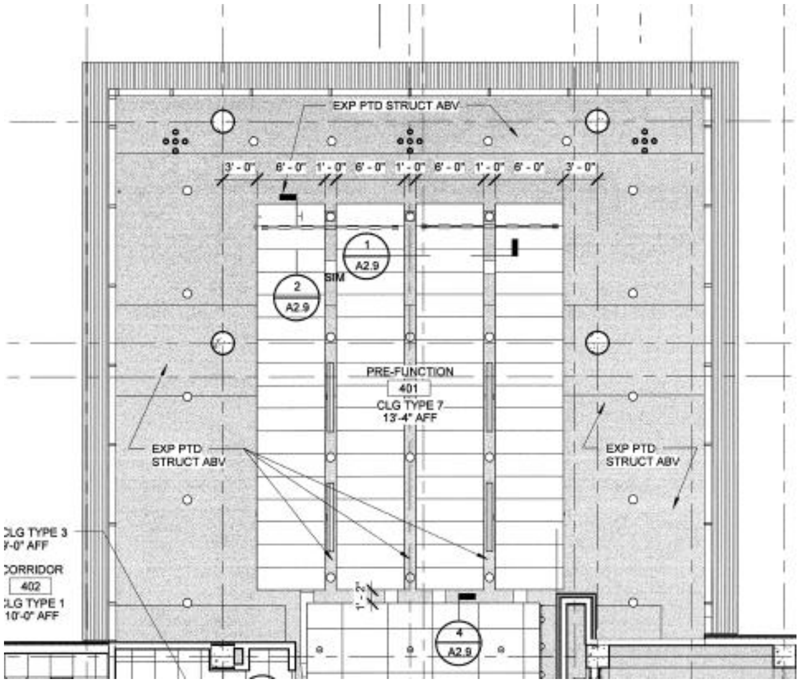


Figure 69: RCP Fourth Floor

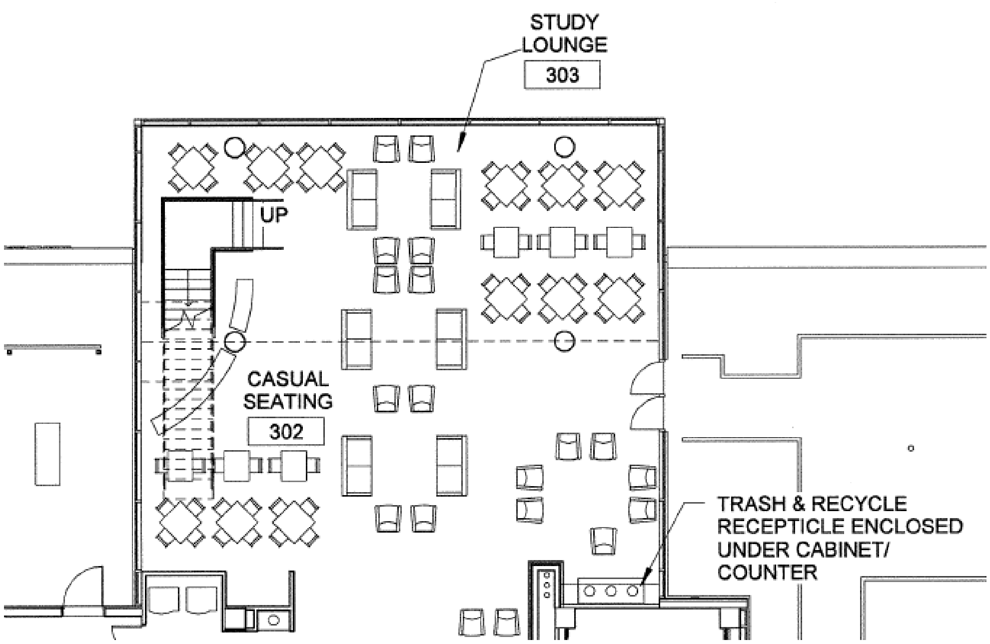


Figure 70: Furniture Plan Third Floor

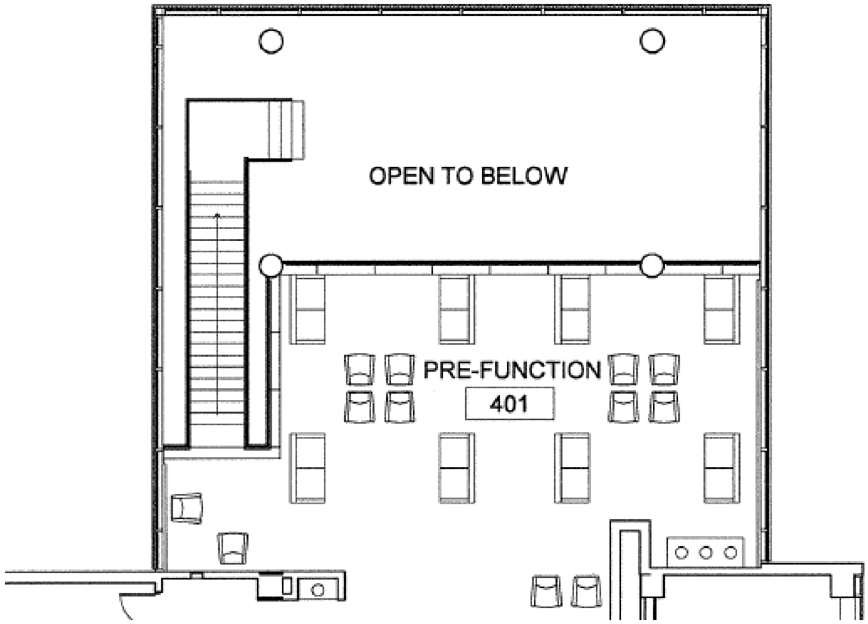


Figure 71: Furniture Plan Fourth Floor

Space Function

The study lounge was designed as the premiere study spot within West Village. As part of the commons building, the study lounge can be used 24 hours by students. Additionally, the balcony area can also be used as a pre-function space for the multi-purpose space. Like the grand stair and lobby, the "cloud" ceiling is carried through the study lounge space, to provide a feeling of spaciousness once deep within the lounge. The glazing on each façade allows for a feeling of outdoor environment while in the space, so students will be looking to use this during the day so they may enjoy the sun while studying.

Design Criteria

Unlike several of the other spaces, the study lounge is classified by the IESNA by its reading tasks. For a typical college student, textbooks, laptops and notes are the typical tasks at hand.

IESNA Categories: Reading: VDT Screens, 8-10 pt print, ball point pen

Very Important

1. ***Reflected Glare (IESNA)***

   Typically problems with reflected glare arise from the use of computer screens or VDTs. To reduce this, VDTs should be arranged in a manner that the luminaire does not reflect off of the screen. Though furniture movement is easiest, lighting should use diffuse lenses along matte finishes on room textures to control reflected glare.

2. ***Direct Glare (IESNA)***

   The study lounge is a large open space. VDT screens are very specular and will reflect the direct glare. Lighting mounted high above should not be a problem unless targeted at a fixed location. Fixtures can be utilized that are lensed so that direct glare from the lamp in avoided.

3. ***Psychological Effect***

   Students will want to be relaxed in and open and spacious environment. With the glazing, the lighting should highlight the transparency to the outside. This will allow for a student to relax and harmonize with nature.

4. ***Daylighting Integration and Control (IESNA)***

   Due to the large amount of glazing surrounding the lounge, sun penetration can cause glare and other visual discomforts. Being able to control the daylight through shades and various types of glazing, promotes the space being used continuously throughout the day.

5. ***Appearance of Space and Luminaires (IESNA)***

   Being a premiere space within the building, the lighting should add to the detail and splendor of the space. It is important not to let the luminaires dominate the space unless for decorative purposes.

6. ***Modeling of Faces or Objects (IESNA)***

   As a gathering space, a person interacting is a primary focus of the lighting design. Groups will use the study lounge to meet and interaction between group members should be under the highest quality light. CCT < 3500K and CRI >85

7. ***ASHARE 90.1-2007 Power Density:*** 1.2 W/sq. ft.

   Because of the LEED accreditation, it will be important not to exceed the ideal power density in order to apply for reduced energy loads. 1.2 watts is the recommended requirements of an educational building. A study lounge is not specified in the space by space method.

Important

1. ***Source/Task/Eye Geometry***

   Constantly changing luminances puts a strain on the eye. Depending on the geometry between the eye and the source, reading can become quite difficult. With high mounted lighting, this should not be a problem within the space. Luminaires should not generally come into view, allowing for an easily maintained luminance ration of 3:1.

2. ***Horizontal Illuminance (IESNA)***

   a. Print and Pen: 30 fc

   b. VDT Use: 3 fc

Design Overview

Concept

The primary goal of the study lounge lighting is to continue the concepts developed in the grand stair and lobby area. Lighting the columns will work with the column lighting created on the first 2 floors. The height of the building is transparent through the clear glazed north wall. An additional ceiling will be created to allow the placement of the pinpoint fixtures. This will make the underside of the roof appear as though it is a field of stars from the quad, continuing to enhance the building's transparency. The linear fixtures and pendant downlights will follow the trend set by the lobby area fixtures. The wood wall will also continue to be highlighted.

Lamp/Luminaire Selection

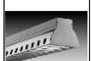
With daylight integration being a major feature of the space, lamps will be selected based on a 3500K CCT. Luminaires selection will match those selected for the grand stair. This space will act as an extension, using the louvered linear fluorescents to create skylights. In the newly created ceiling, round downlights will be featured to help illuminate the task plane at 28' below. All fixtures will try to use similar lamps to play an easy roll in maintenance of fixtures.

Light Loss Factors

Table 20: Lounge Light Loss Factors

	BF	LLD	LDD	Total
L1	1.00	0.85	0.92	0.78
L2	1.00	0.85	0.85	0.72
L3	1.00	0.84	0.92	0.77
L4	1.00	0.80	0.92	0.74
S1	1.00	0.80	0.92	0.74
S2	1.00	0.95	0.92	0.87
S3	1.10	0.95	0.85	0.89

Fixture Schedule

Luminaire		Classification	Mounting	Lamp		Ballast	Voltage	Watts	Description	Fixture
L1		8" CFL Recessed Downlight	Ceiling Recessed	(2) GE F32TBX/835/A/ECO	3500K, CRI = 82	GE GEC242-MVPS-BES	277	63	8" Round Aluminum housing. Matte-Diffuse reflector. 277V electronic ballast.	Gotham Lighting AF-2/32TRT-8WR-LD-277
L2		9" CFL Surface Downlight	Surface Mounted to Exposed Ceiling	(2) GE F32TBX/835/A/ECO	3500K, CRI = 82	GE GEC242-MVPS-BES	277	63	9.5" Round Housing White Finish, 0.05" thick aluminum. Two Socket 277V Electronic Ballast	Portfolio C19-2-32-E-P-9250-W
L3		9" CFL Surface Downlight	Surface Mounted to Exposed Ceiling	(2) GE F42TBX/835/A/ECO	3500K, CRI = 82	GE GEC242-MVPS-BES	277	93	9.5" Round Housing White Finish, 0.05" thick aluminum. Two Socket 277V Electronic Ballast	Portfolio C19-2-42-E-P-9250-W
L4		2.25" LED Recessed Downlight	Ceiling Recessed	Integrated LED	119 lms/ ft 3500K	Juno TL602E-60-WH (Driver)	120	5	2.25" Round Diecast housing. Integral LED 3500K at with 24 degree beam spread. 120V to 12VAC transformer.	Juno Lighting Group MD1L-35K-NFL-WH
S1		2'-0" Color Changing LED Strip	Surface Mounted	Integrated LED	RGB LEDs	N/A	120	35	2' RGB LED strip with 10 deg by 60 deg beam spread. Indoor Rated. Internal Driver for 120V connection.	Philips Color Kinetics 2-RED-GREEN-BLUE-10x60
S2		4'-0" Direct Flourescent Pendant	Pendant Mounted at Adjacent "Cloud" ceiling Height	GE F32T8/SPX35/ECO	3500K, CRI = 86	Advance VEZ-132-SC	277	35	4' Linear Parabolic Downlight with one piece 0.09" thick aluminum body. 1.5"H x 2.5" frequency prabolic louver. Reflectro with semi-specular finish. 277V electronic dimming ballast.	Focal Point FW1-PL-1T8-1C-277-E-RC-WH-4
S3		4'-0" Wall Mounted Wall Grazer	Wall Mounted: See Detail	GE F32T8/SPX30/ECO	3000K, CRI = 86	Advance VEL-2P32-SC	277	38	4' Linear Cove fixture. 20 gauge steel housing and 24 gauge reflector. High Reflectance White Power Coat on Reflector. 277V electric ballast.	Focal Point FW1-PL-1T8-1C-277-E-RC-WH-4

Mounting Detail

See Lobby and Grand Stair Lighting Redesign for Grazing and Column Detail.

Design Performance

Criteria Evaluation

The study lounge is the key space from the student perspective. With its placement on the third and fourth floors, it is also the focal point of the quad. The concept developed in the lobby was carried through to this space. The cloud ceiling concept was carried through the space. The clouds above the balcony were trimmed back to ending at the edge of the balcony. A new drop ceiling was placed at 28' above the finish floor open the area of the lounge. See the lighting layout plan for new ceiling layout. This allowed for the placement of small recessed fixtures to act like stars within the space. Column lighting and details are continued from the lobby. The overall space is uncluttered with fixtures by surface mounting or recessing all lighting. Additionally, the wood texture is drawn out through wall grazers to highlight the surface. Lighting focused mainly on the interior of the space and maintained the transparency into and out of the space. The integration of the space with daylighting is analyzed later in the report. Illuminance values were taken at a workplane height of 2'-6" for the balcony area, open area, and under balcony area. All three were targeted to meet 30 fc. The average illuminance values are lower than the target of 30 fc because of the glazing. With little reflect from the glass, low values are obtained near the perimeter of the space. When these values are removed, the illuminance value meets target levels.

Illuminance

Under Balcony: 25.16 fc

Balcony: 26.82 fc

Open Area: 29.12 fc

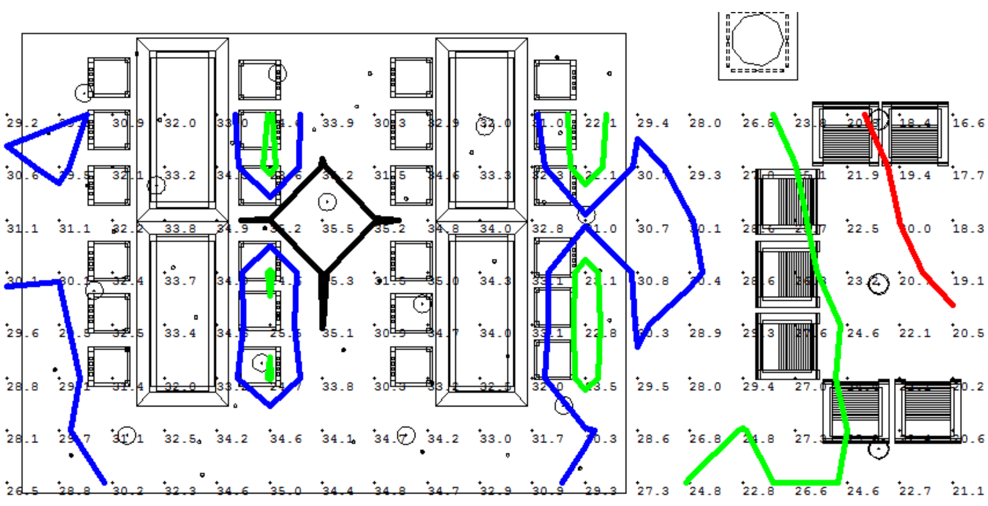


Figure 72: Open Area Illuminance Values

The isoline values shown above are as follows; Black = 35 fc, Blue = 30 fc, Green = 25 fc, Red = 20 fc.

Lighting Power Density

The lighting power density with decorative lighting is 1.2 W/ sq. ft. for the space. This is the level specified by ASHRAE 90.1-2007. Because the terrace power density is over the limit, it can be traded to the study lounge. Decorative lighting would include the min LED recessed fixtures and the colored LED column lighting. Because of them, and additional 1.0 W/sq. ft. can be added to the space. The final lighting power density is required to be fewer than 2.2 W/ sq. ft. to comply.

Table 21: Lounge Lighting Power Density

Luminaire	*Quantity*	*Watts(W)*	*Required Power (W)*
L1	12	35	420
L2	10	65	650
L3	6	85	510
L4	204	5	1020
S1	32	35	1120
S2	18	35	630
S3	8	35	280
		Total Power	3956
		Square Foot	3860
		LPD	1.20 W/sqft
		ASHRAE	2.2 W/sqft

Renderings

Figure 73: Interior View of the Lounge.

Figure 74: Wall Grazing

Figure 75: Perspective of the Lounge with normal lighting scheme.

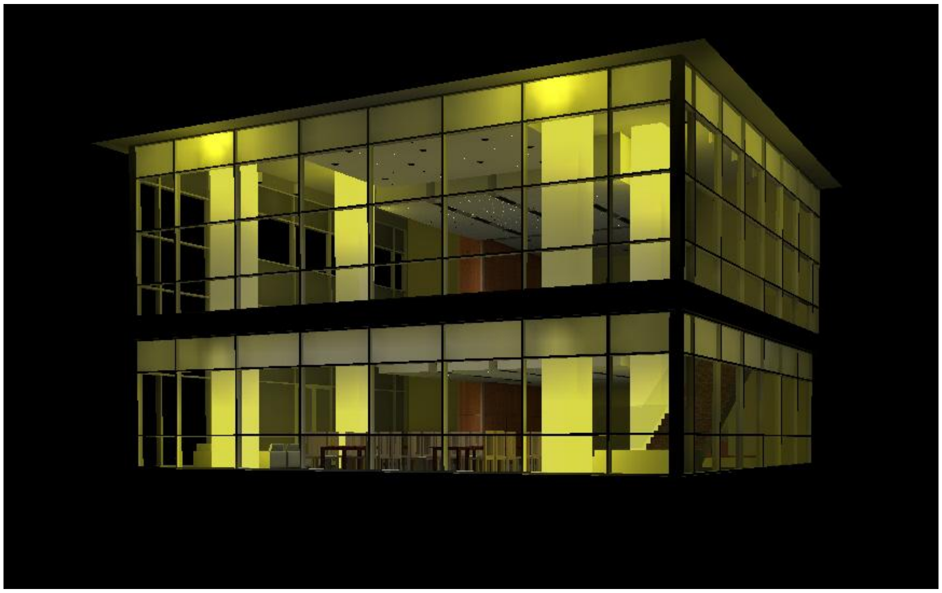
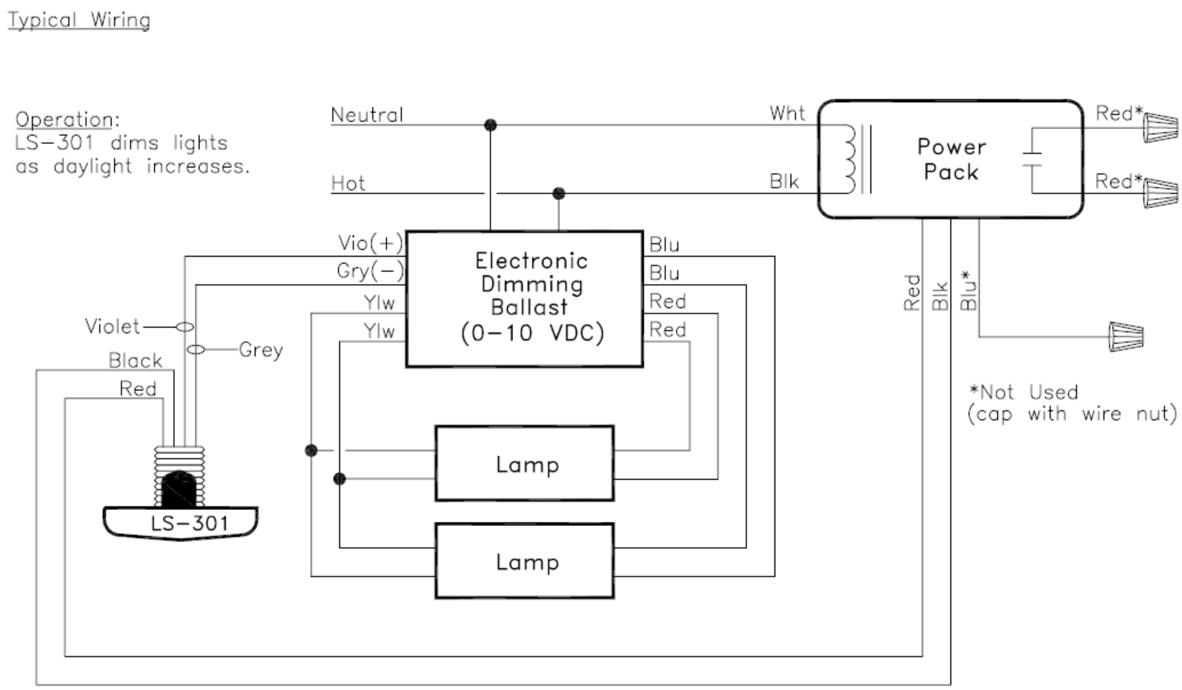


Figure 76: Color Changing Columns

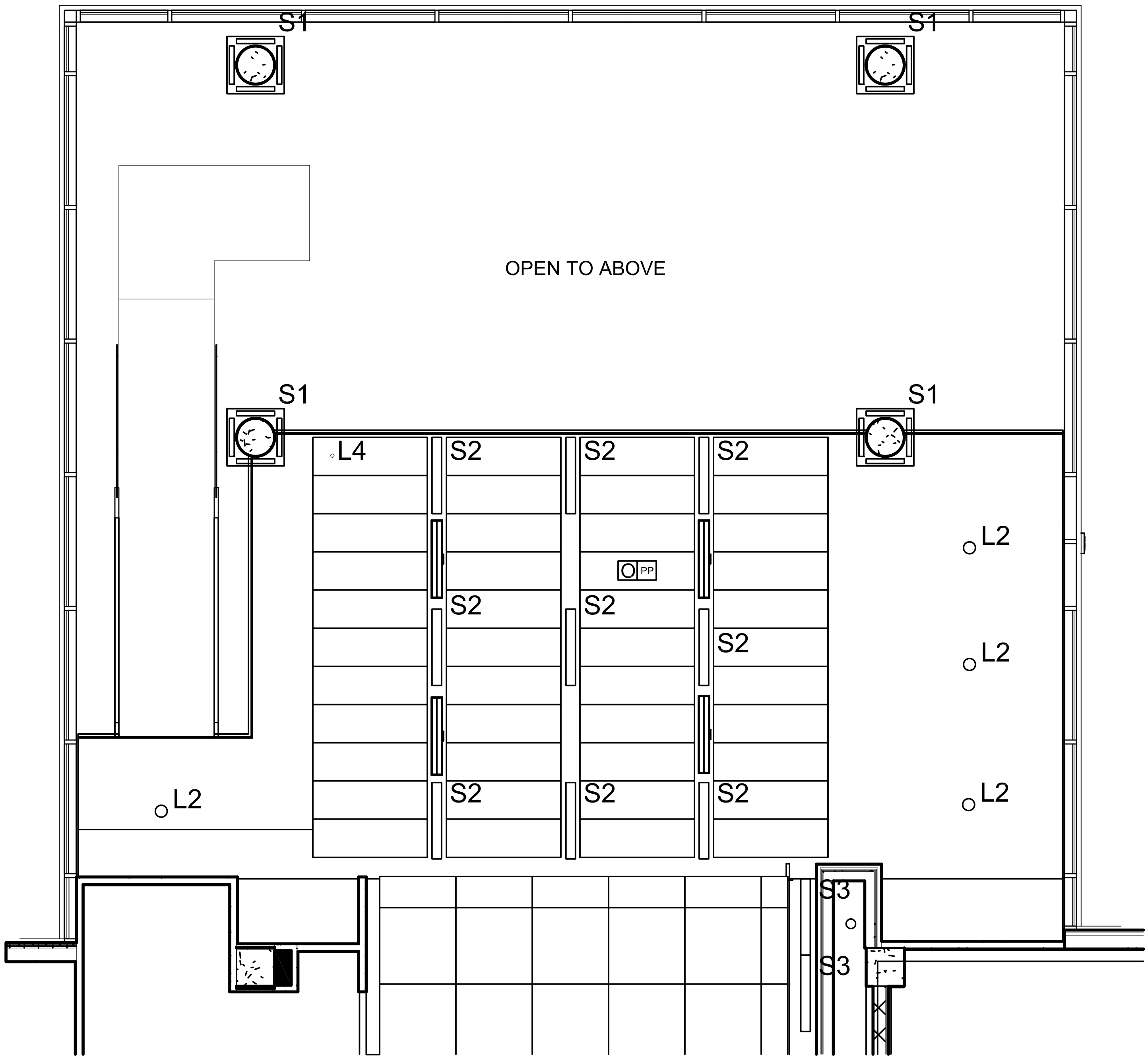
Figure 77: Starlight Ceiling

Control System

The primary control of the space will be the building automation system. The fluorescent lighting above the balcony and under the balcony will use a daylight sensor to control the light levels. This will be integrated with the building system. Shading controls will be independent of the lighting system.



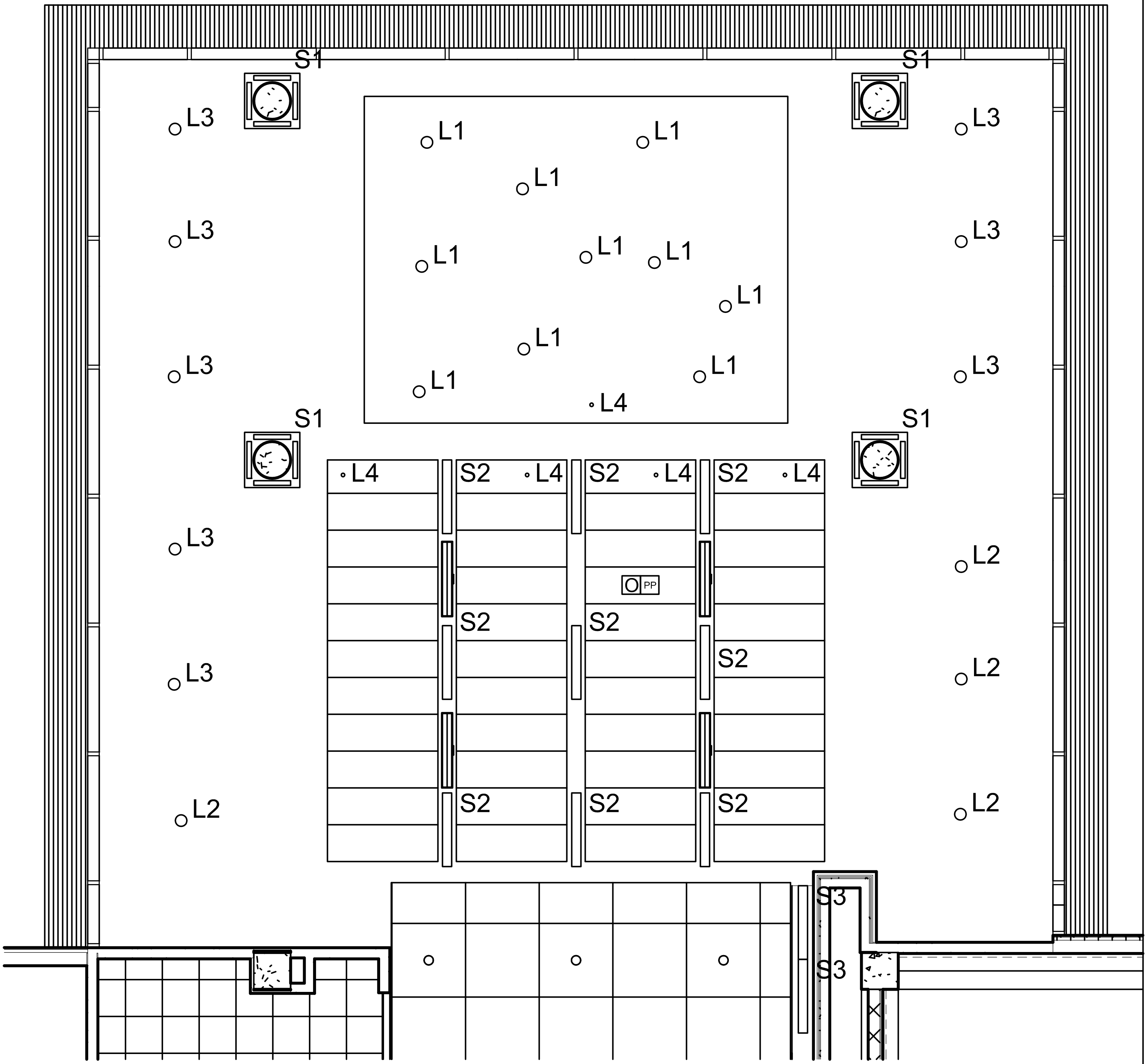
Tag	Manufacturer	Catalog Number	Description
D	Watt Stopper	LS-301	24VDC Dimming Daylight Sensor mounted to ceiling at 12'-0".
ER	Philips	GTD20A	Emergency Lighting Transfer Relay. Circuit to Emergency Panel without switching. Relay shall be rated for 20-Amperes of lighting load.
PP	Watt Stopper	BZ-50	20A Load Power Pack to supply power to dimmer.



NOTES

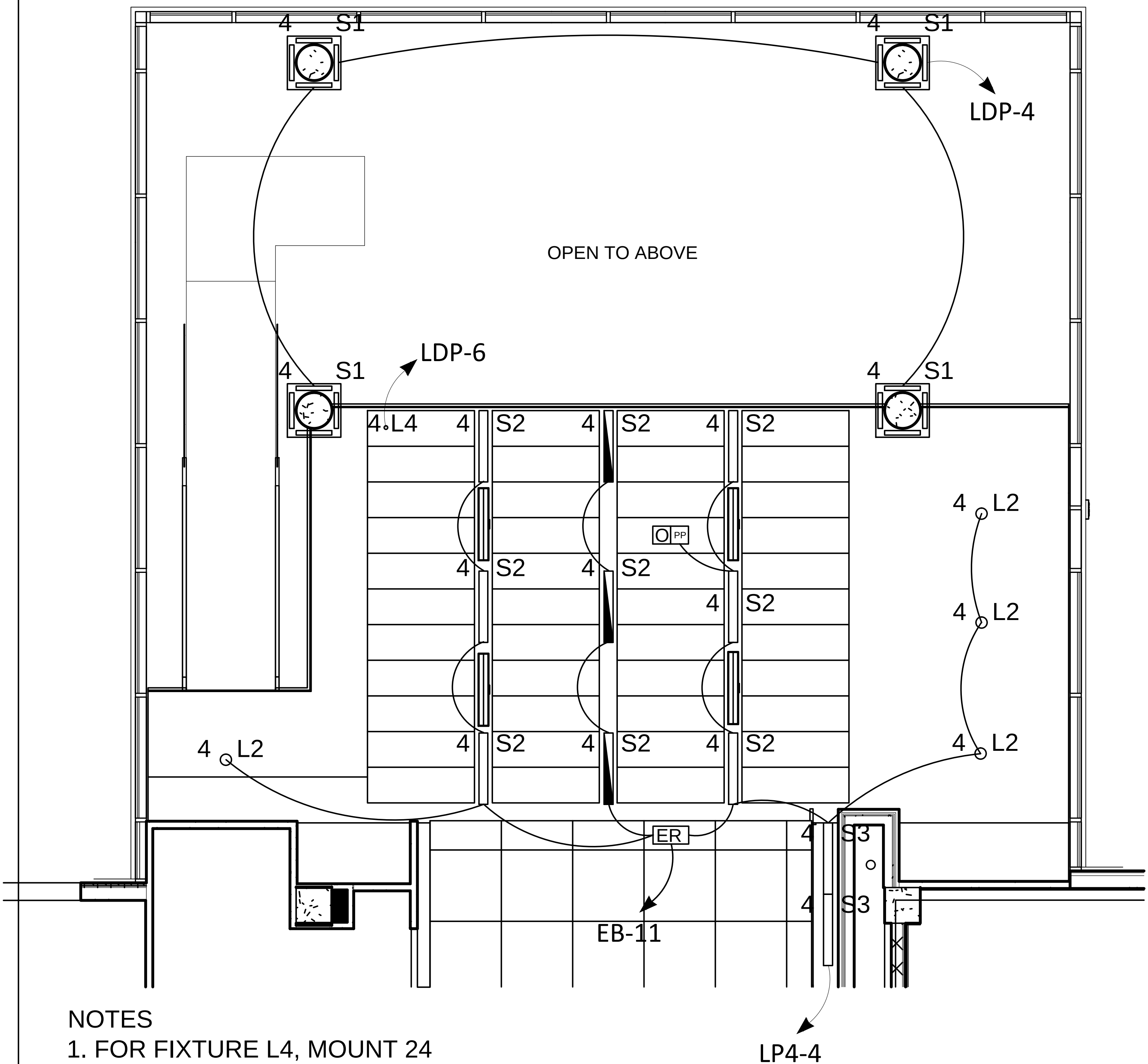
1. FOR FIXTURE L4, MOUNT 24 FIXTURES PER CLOUD. EACH CLOUD TO USE 2 TRANSFORMERS PLACE IN CEILING CAVITY.WIRE TO DECORATIVE LIGHTING IN COLUMNS.
2. WIRE 12 L4 FIXTURES PER DRIVER TO INDEPENDENT CIRCUIT ON NEW PANEL LDP.

	LOUNGE LIGHTING PLAN 1
	SCALE: $\frac{1}{8}$" = 1'-0"
E1.5A	AE 497G/882
	PATRICK MORGAN
	APRIL 7, 2011



NOTES
1. FOR FIXTURE L4, MOUNT 24 FIXTURES PER CLOUD. EACH CLOUD TO USE 2 TRANSFORMERS PLACE IN CEILING CAVITY.WIRE TO DECORATIVE LIGHTING IN COLUMNS.
2. WIRE 12 L4 FIXTURES PER DRIVER TO INDEPENDENT CIRCUIT ON NEW PANEL LDP.

	LOUNGE LIGHTING PLAN 2
	SCALE: $\frac{1}{8}$" = 1'-0"
E1.5B	AE 497G/882
	PATRICK MORGAN
	APRIL 7, 2011



NOTES

1. FOR FIXTURE L4, MOUNT 24 FIXTURES PER CLOUD. EACH CLOUD TO USE 2 TRANSFORMERS PLACE IN CEILING CAVITY.WIRE TO DECORATIVE LIGHTING IN COLUMNS.

2. WIRE 12 L4 FIXTURES PER DRIVER TO INDEPENDENT CIRCUIT ON NEW PANEL LDP.

LOUNGE POWER PLAN 1

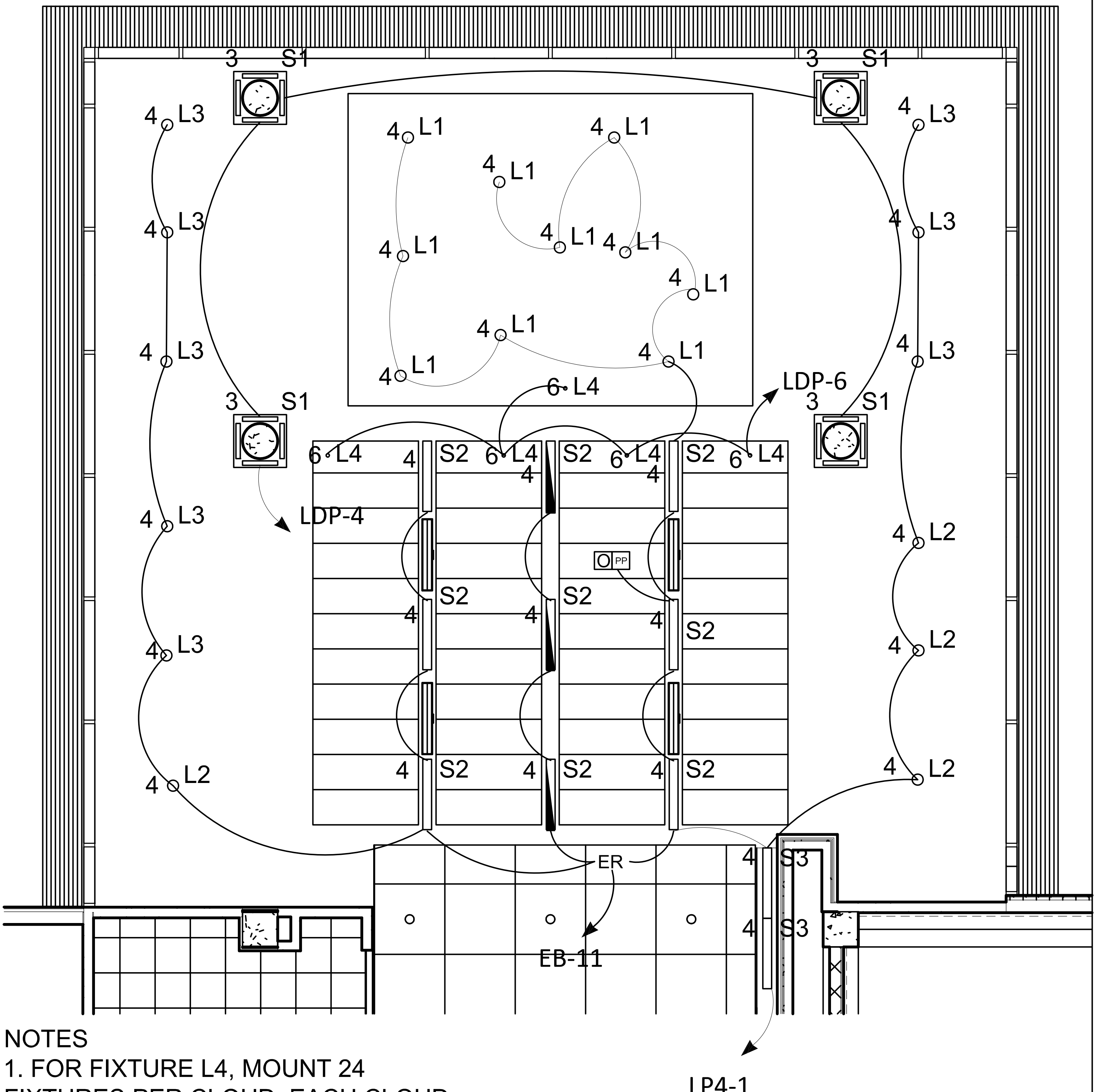
SCALE: $\frac{1}{8}$" = 1'-0"

AE 497G/882

E2.5A

PATRICK MORGAN

APRIL 7, 2011



NOTES

1. FOR FIXTURE L4, MOUNT 24 FIXTURES PER CLOUD. EACH CLOUD TO USE 2 TRANSFORMERS PLACE IN CEILING CAVITY.WIRE TO DECORATIVE LIGHTING IN COLUMNS.
2. WIRE 12 L4 FIXTURES PER DRIVER TO INDEPENDENT CIRCUIT ON NEW PANEL LDP.

E2.5B	LOUNGE POWER PLAN 2
	SCALE: $\frac{1}{8}$" = 1'-0"
	AE 497G/882
	PATRICK MORGAN
	APRIL 7, 2011

MAE Focus – Lounge Daylighting Analysis

Introduction

On the 3rd and 4th floors, at the North end of the building, is the student study lounge. The lounge is designed with three all glass exterior facades. These facades range in glass types from fritted to clear glass, depending on how the sun will hit the surface. The building is rotated east of north by 11 degrees. This affects how each of the facades will see the sun. The east glazing consists of mostly fritted patterns. The north and west glazing use a clear glass. Because of the study lounges overlooking views of the quad and residence halls, it is important to preserve the views as much as possible. The lighting redesign shown earlier in this report uses the transparency of the building to integrate it with the surrounding hillside. With access through to the roof terrace, it is also important to maintain transparency between the spaces. Students will want to move in and out as the weather changes throughout the year. It is also important to feel connected to the outdoors with more than the use of wood throughout the space. The daylighting analysis of this space will put a primary focus on maintaining high transparency with the outside, while creating an indoor daylit environment.

Table 22: Daylight Glazing Properties

Glazing	Type	SHGC	Transmittance	Reflectance
GL-3	Clear	0.38	70%	11%
GL-4	Translucent	0.37	60%	12%
GL-5	Frit	0.30	44%	22%

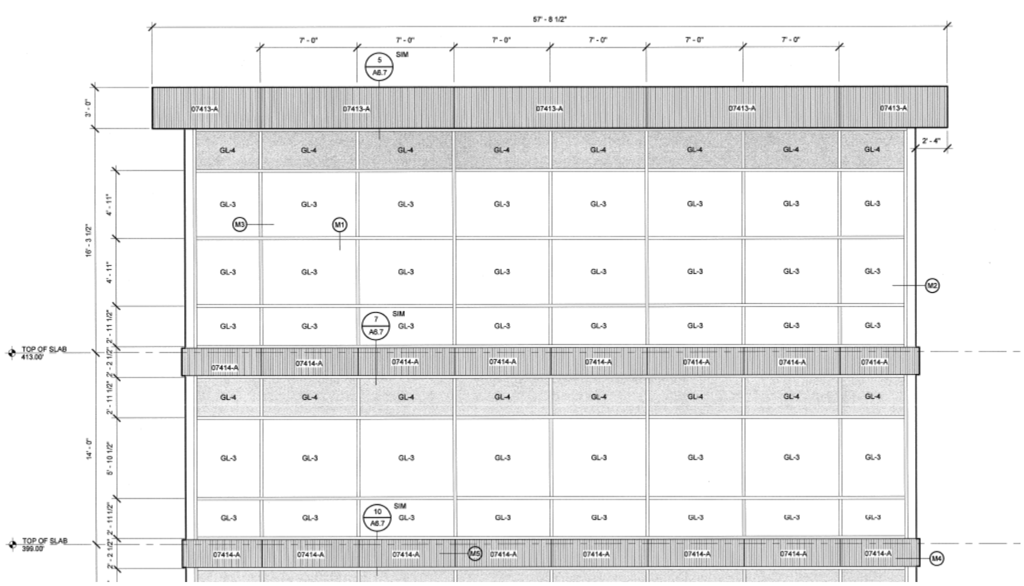


Figure 78: North Facade

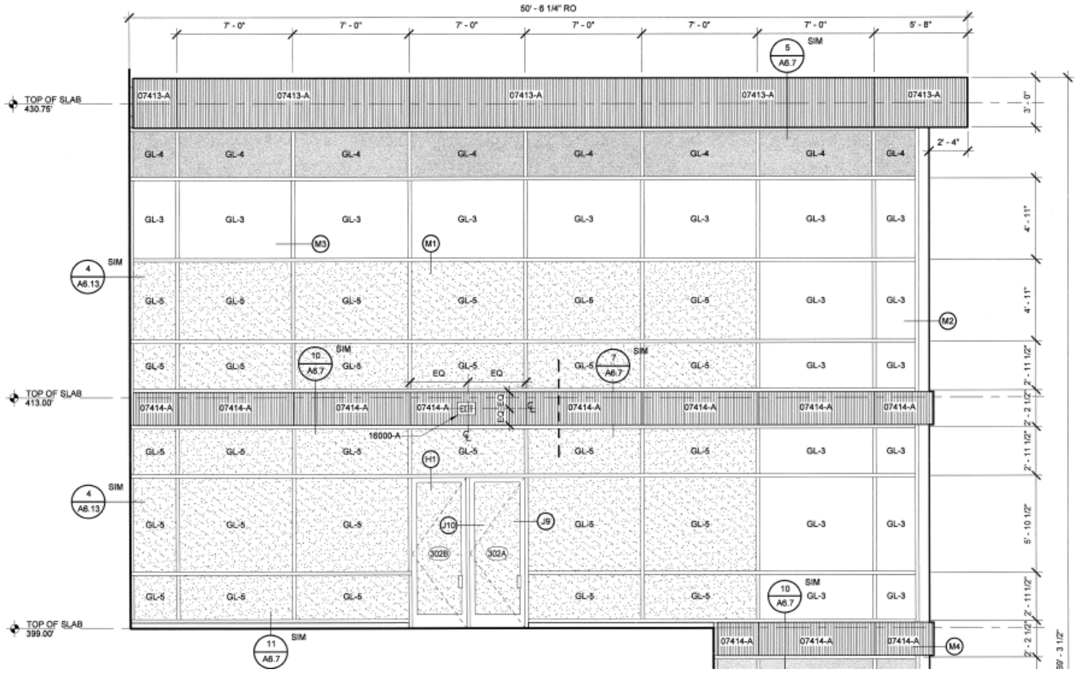


Figure 79: East Façade

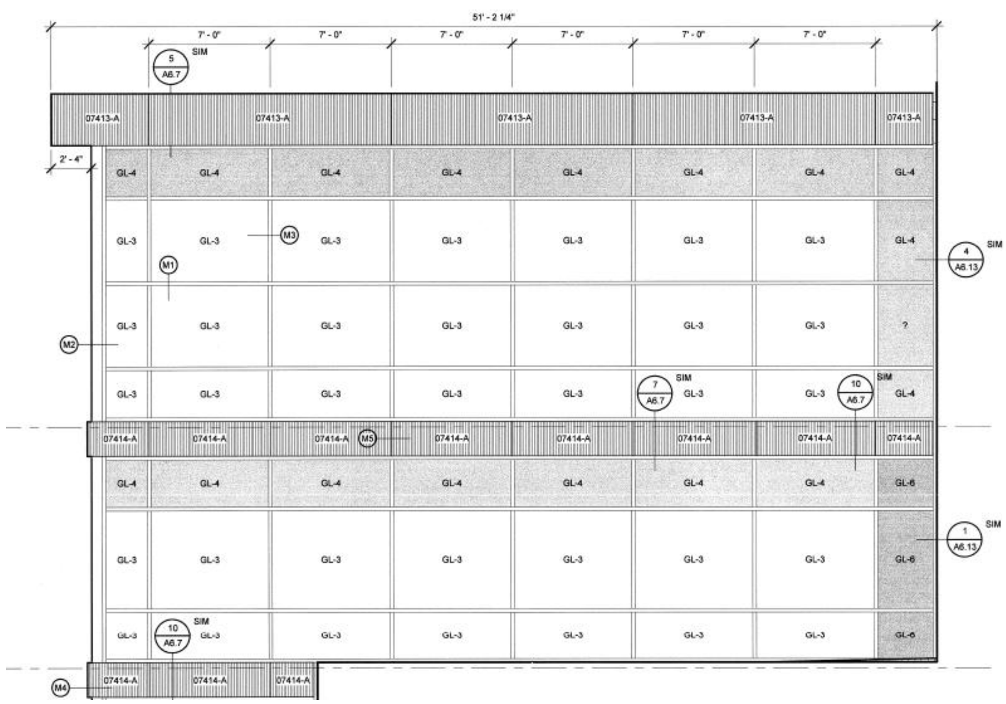


Figure 80: West Façade

Illumination Study

Using the model developed during the lighting redesign, the space was initially studied for illuminance levels within the space. The study included illuminance levels during the spring equinox at noon for both clear and overcast sky conditions. Through using AGi32, multiple analysis grids could be created to look at lighting levels on both levels on the study lounge. This is important to see where ambient light from the North has the most affect. The lighting system included in the redesign target for 30 fc.

Table 23: Average Footcandles

	Overcast	Clear Sky
Main Study Area	244.74	349.94
Covered Area	83.12	137.89
Balcony	92.44	220.63

Table 24: Minimum Footcandles

	Overcast	Clear Sky
Main Study Area	187	254
Covered Area	27.9	67.3
Balcony	56.4	136

Under both sky conditions, even the deepest points within the room receive enough light to meet ideal illuminance calculations. Since the space will be primarily used by students, the space will need to effectively control the daylight so they can study in a relaxed environment. As human culture pushes toward use of computers for the majority of reading and writing in college, glare becomes an even greater issue. During AE 565, a useful illuminance cap was developed. Above 2000 lux, daylight can cause visual discomfort. This is especially true for direct light. Daylight Autonomy takes into account whenever a calculation point meets or exceeds the preset level of light. As can be seen in the graphic below, the fritted pattern helps to deter this from happening in parts of the lounge. The problem is that the general study area that is close to the North façade is greatly affected by high levels of daylight. An in-depth profile analysis of each façade can help determine the optimal placement for shading and its resultant control system.

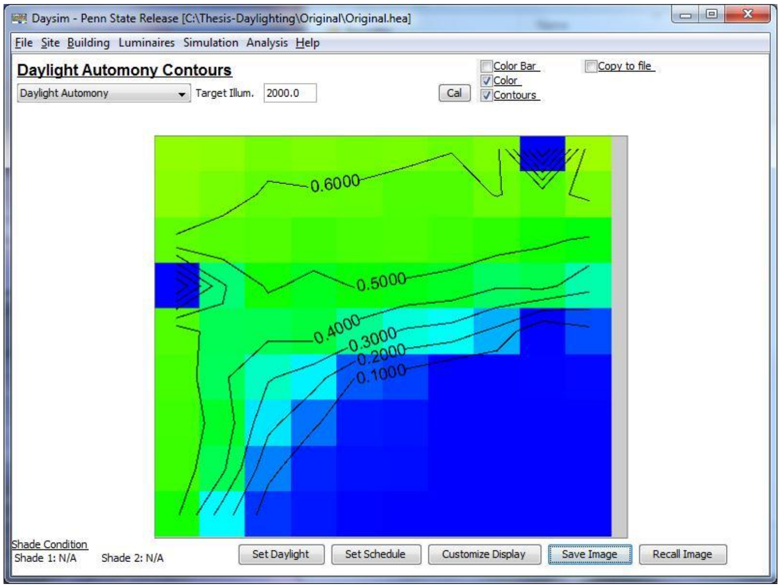


Figure 81: DAYSIM - 2000 Lux Daylight Autonomy

Profile Analysis

Each curtain wall of the study lounge was process through an excel spreadsheet to determine when direct light would pass into the space. The results can be seen in the graphs below. Area below the curve will see direct sun penetration. Overall, the east wall will receive the most direct penetration throughout the year. This will occur mainly from sunrise till about solar noon. As this is a commons building, students will be arriving for breakfast and may use the lounge in between classes and heavily throughout the morning. Student activities will most likely focus around studying and working on class work, so computer work will be heavily relied on. Additionally at the end of the day, a popular meeting and studying time for students, daylight will also deeply penetrate into the space.

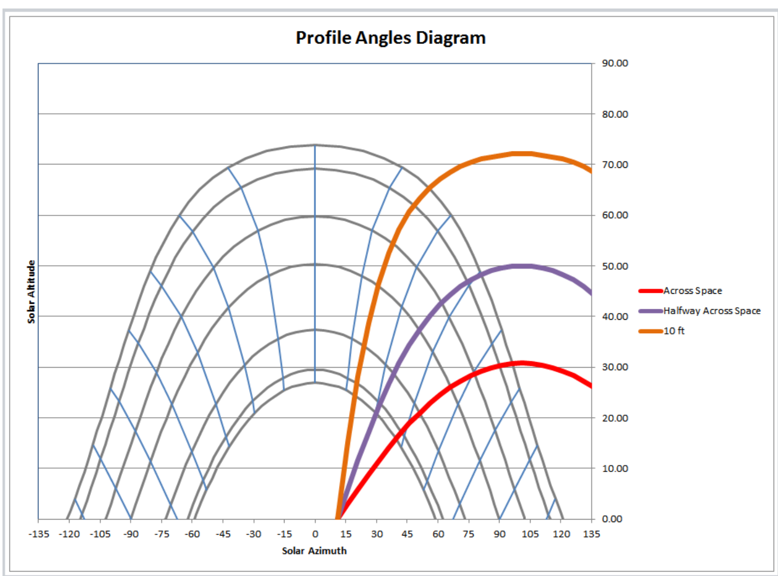


Figure 82: West Wall Profile

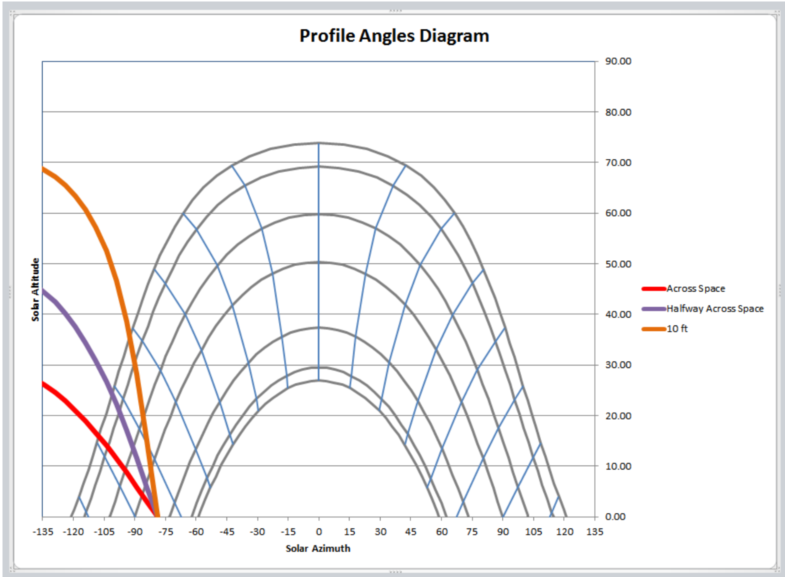


Figure 83: North Facade Profile

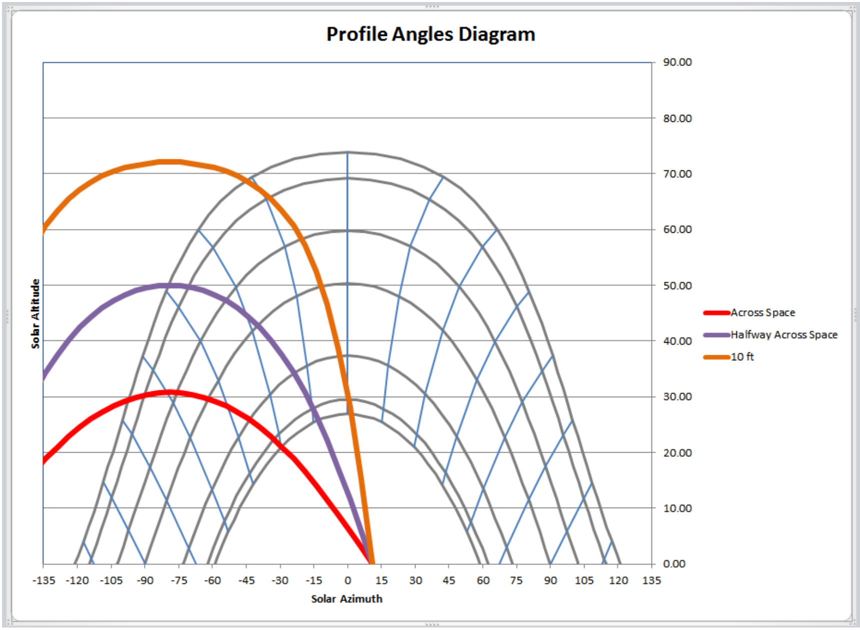


Figure 84: East Facade Profile

Implemented Solution

Internal shades, integrated with the dimming system will be the optimal solution. Shades will work to preserve the views through openness factors and transmittance. As less direct light penetrates the lounge, the balcony area and under balcony area will require electric light. Both the east and west facades would benefit from interior shades. The north would only be minimally affected by direct sun. Additional interior shades on the north could be installed, but would be manually controlled by the occupants. Additionally, the specified glass has an extremely high transmittance.

All facades will instead use a clear glass with a transmittance of 47% to preserve the views to the terrace and quad. Glazing 4 will not be changed as it is a decorative glass that continues around the buildings perimeter. Shading will be controlled by IR Sensors provided by manufacturer and touch pad.

Shade Properties: Lutron SheerLite

Reflectance: 11%

Transmittance: 9%

Openness: 3%

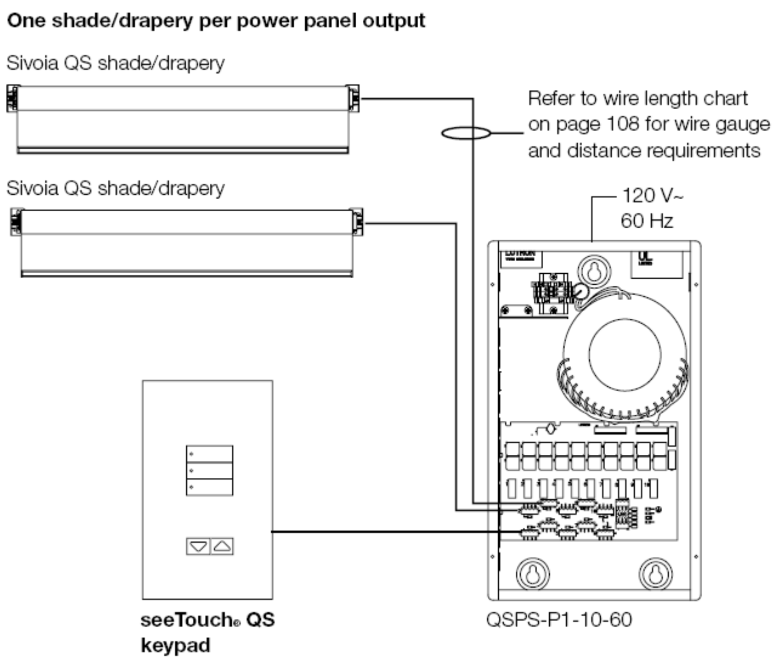


Figure 85: Basic Shading Control Diagram

System Model

The Study Lounge was modeled in CAD and exported to DAYSIM for analysis. The materials and lighting design match those specified in the lighting redesign portion of this report. The occupancy of the lounge was developed in accordance with the Towson Academic Calendar. A typical occupancy for the school year is 70% use between 7 am and noon, 90% used between noon and 9 pm, and 50% between 9 pm and midnight. A shade was placed along the entire east façade of the lounge. The shade material details can be seen in the table below. The dimming senor will use a closed loop sensor to effectively balance out the light for the under balcony space. An open loop sensor directed towards the critical point for the shading controls. An open loop sensor will only take an input from daylight and will be placed within the 10 ft range of the window.

Model Results

The shading system effectively reduced the amount of light within the space. As the time of day changes the east shades will rise and the west shades will lower, as if tracking the sun. The metric of continuous daylight autonomy is the measure of daylight contribution to the space over the occupancy times. Each space accounts for the hour when it reaches a certain value and also gives partial credit to when illuminance levels are below the set point. For the study lounge, the set point was 30 fc or 323 lux. The graph below is results of the continuous daylight autonomy of the space with the shades turned on based on signal.

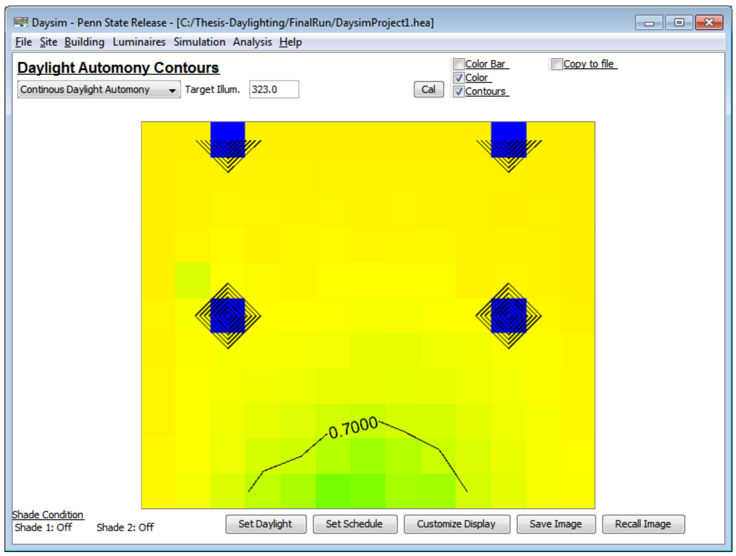


Figure 86: Continuous Daylight Autonomy at 30 fc. No shades.

The continuous daylight autonomy is almost completely covering the base floor of the study lounge with uniformity. This value may be higher is the occupancy file was set to only operate during hours when daylight is available. As studied above in the original design, it is useful to see how much of the continuous daylight is useful. Below are the results of the daylight autonomy at 2000 lux. Daylight autonomy is the metric used to see when a calculation point reaches at the level of light or above, without taking partial credit into account. This is useful because it can show where daylighting can cause glare conditions.

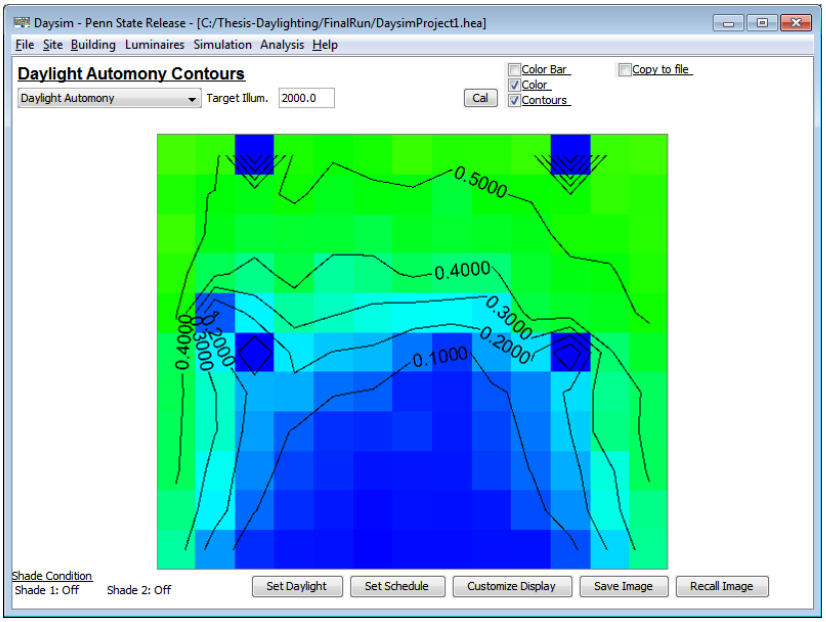


Figure 87: 2000 Lux Daylight Autonomy. No shades.

The open area of the study lounge receives over 2000 Lux for half of its occupancy. Though this is along the north façade, the daylighting levels will need to be decreased in this area. Under balcony area will rarely see high illuminance levels with the change of glass. The overall conditions have improved form the initial glazing.

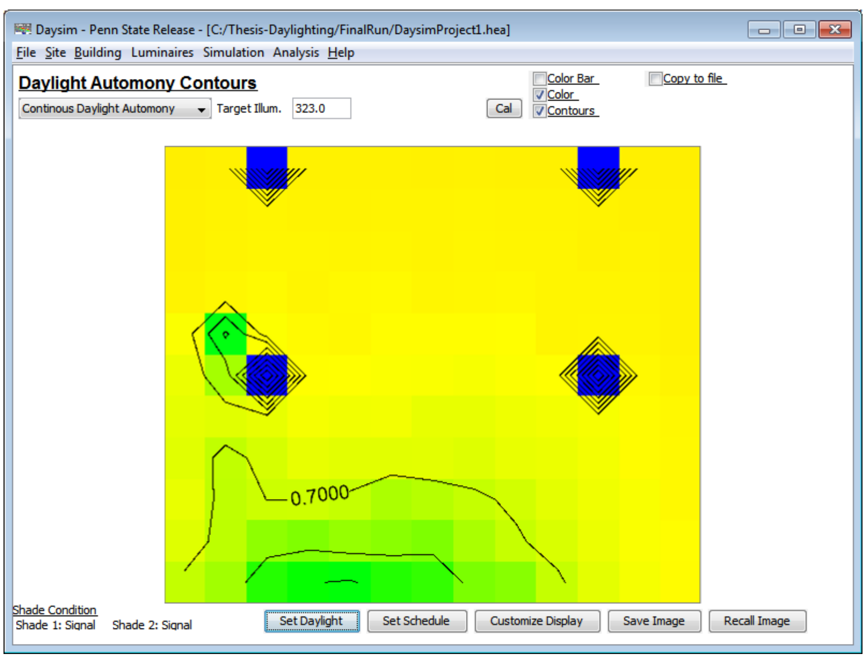


Figure 88: Continuous Daylight Autonomy at 30 fc with shades.

The space looks relatively the same when the shades signals are set. Using open loop sensors, the shade controls were placed along the glazing. Open loop sensors were chosen based on their ability to only take input from the daylight. Since the space will have more than the adequate illuminance with shades down, the electric light near the east and west façade can be turned off by the buildings automation system.

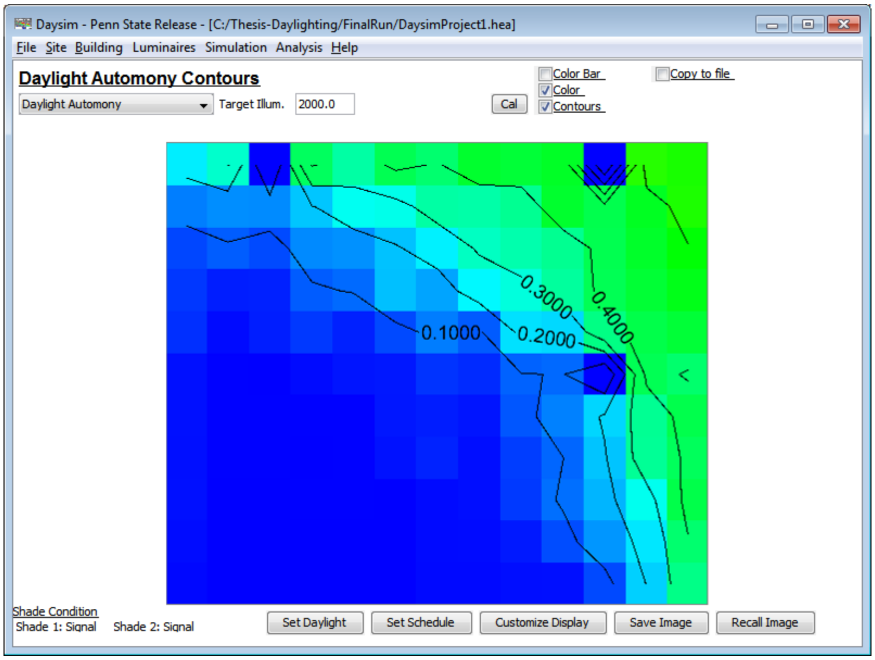


Figure 89: 2000 Lux Daylight Autonomy With Shades

Above is daylight autonomy of the space at over 2000 Lux. From the no shading condition, the results have improved from original conditions. While some daylight is still over 2000 Lux, this can be attributed to the buildings rotation. With a rotation of 11 deg east of north, direct sun will penetrate the space during solar noon. This is typically when the sun is brightest. The shade will be seeing extremely high levels of daylight, and while it will transmit only a fraction of the light, it will be enough to increase the light levels. Students may not be comfortable sitting directly next to the east wall glazing, but the rest of the space will still be enjoyable. As with many students, studying will not be taking place until later in the day and in the evening. The sun will have shifted by this point so the western shades can limit the illuminance level of the space.

Dimming Control

To further study the space, the under balcony area will be controlled through dimming. Because the space will only receive direct light when the sun is low to the east or west, most of the space will need additional lighting throughout the year. By using a closed loop proportional sensor, the signals for daylight and electric light will be accounted for by the sensor. Below is the selection of the critical point for the photosensor. Based on weather data, sun rotation, and the symmetry of the daylighting effect in the space, the point was selected. This point is at about 60% dimming. When setting a sensor, the dimming should be above its minimum condition, but plenty of daylight should also be present. The point selected was analyzed for accuracy at representing the space.

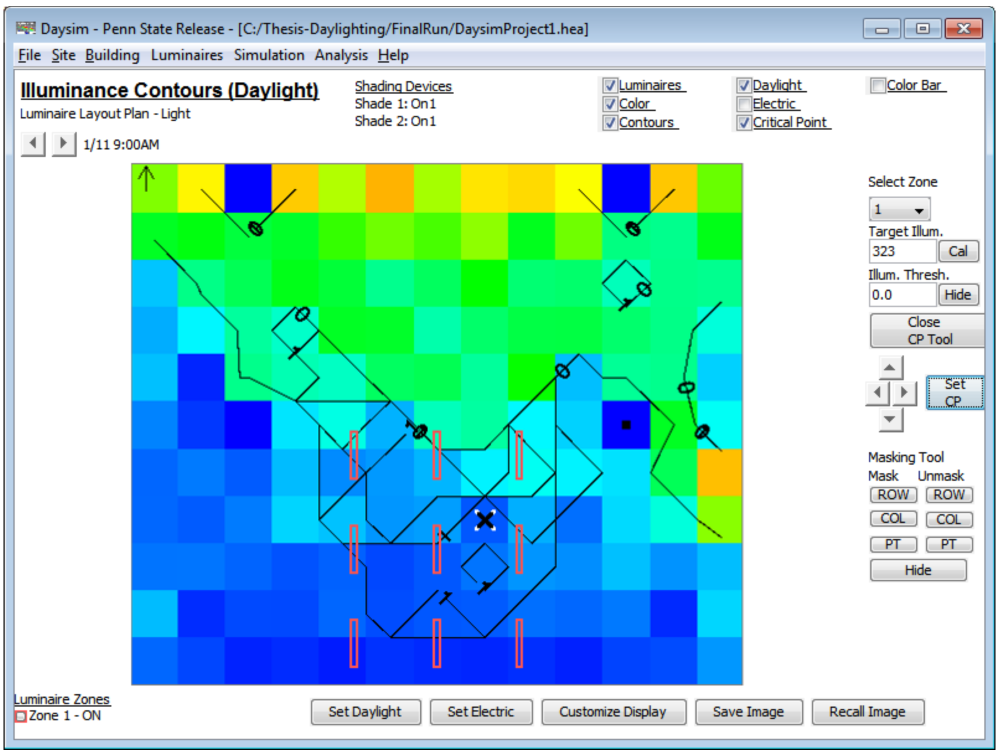


Figure 90: Critical Point for Photosensor

The photosensor's performance can be seen on the next page. Overall, the photosensor converged towards a line. Erroneous points show that the sensor will be providing various levels of light as the same dimming level. The optimal condition would to have every point fall in-line of the rest of the points. This will hardly ever happen, as the daylight signal to illuminance ratio will continually change. To further see the performance of the system, the algorithm vs. optimal graph was used for a random week throughout the year. The algorithm matches the optimal condition over the week, meaning the sensor will provide a energy savings. The optimal condition will save the most energy.

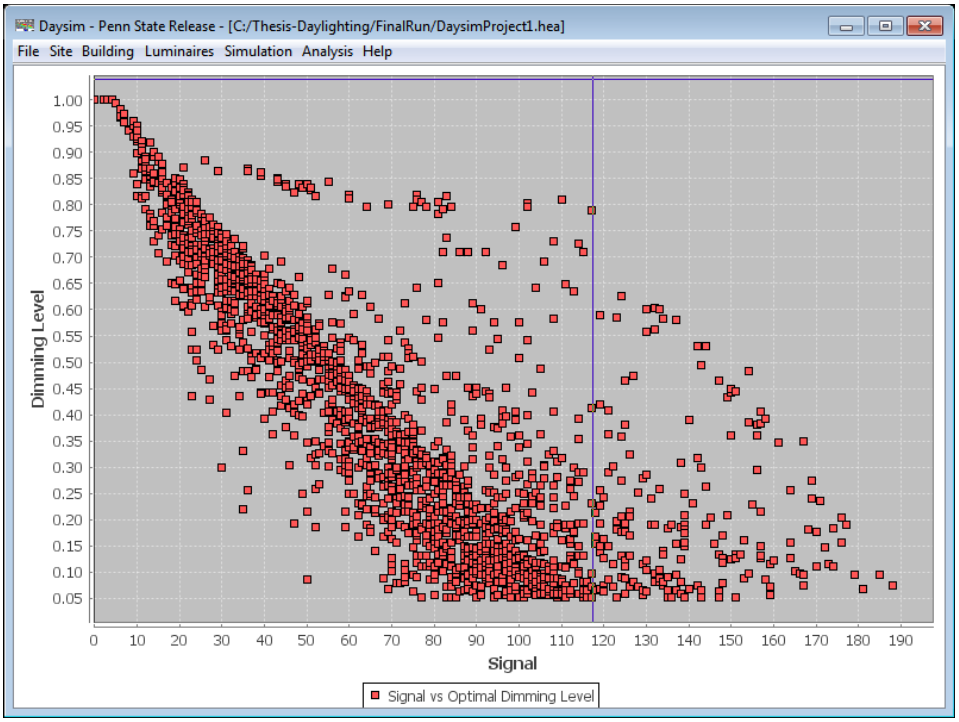


Figure 91: Signal vs. Dimming Level

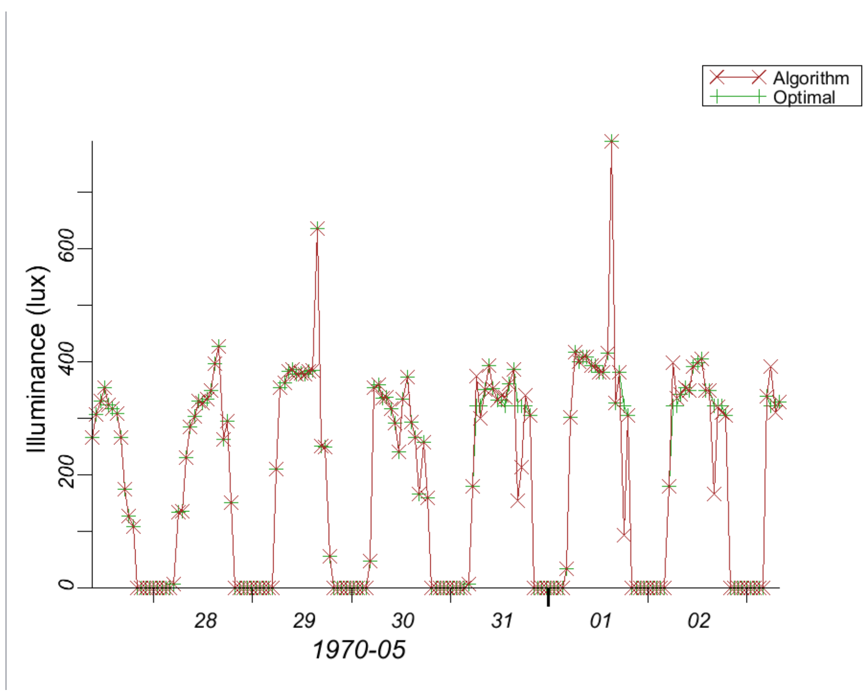


Figure 92: Algorithm vs. Optimal Conditions

Conclusion

Shading is effective at reducing the illuminance levels that have glare possibilities. Without using the electric lighting system, daylighting can provide effective illuminance levels within the space. Additionally, changing the glass also added in helping to preserve the view while reducing the high light levels within the space. Daylight can be effectively controlled within the space to provide a comfortable study environment during the day.

Dimming the under balcony lighting also resulted in savings. As seen below, the yearly kWh of energy consumption can be reduced by 414.12 kWh. While this may be over the optimal sensor performance, this is a substantial reduction for a space that will be put to use almost 24 hrs a day. When combining shading and dimming solutions, the student lounge becomes the premiere daylit space to study in a comfortable environment.

Energy Tables (KWh)

Controlled Zone | Grand Total

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Base	4.14	113.46	97.52	121.43	99.35	54.81	54.81	13.27	121.74	125.57	109.63	85.09	1000.86
Optimal	3.25	76.36	57.3	66.37	52.1	23.34	23.92	6.87	70.66	77.58	78.75	63.56	600.1
Algorithm	3.21	75.16	56.78	63.17	49.59	21.43	21.39	6.23	68.58	77.36	79.07	64.72	586.74
Savings	0.92	38.3	40.74	58.25	49.75	33.37	33.41	7.04	53.16	48.21	30.56	20.37	414.12

Figure 93: Daysim Energy Analysis

Breadth 2 – RTSM Load Analysis (Mechanical)

Introduction

To continue the analysis of daylighting's impact on the study lounge, the thermal load changes will be analyzed. Both the change in glazing and the addition of shades have the potential to change the loading characteristics of the space. During the winter, heating loads are defined at midnight on the coldest night of the year. For cooling loads, the design is different. Cooling loads look at the greatest loading on the space from occupants, equipment, and heat transfer from the outdoor environment. This is usually during the summer months at midday. Of those loads, solar gain is the most prevalent. Solar gains within the space happen in both a radiative and convective capacity. Many energy simulation models work well at predicting loads within the space. For this study, the component that needs to be analyzed is the solar gain within the space. A very accurate way of modeling this component is through the Radiant Time Series Method or RTSM method. This method has been adopted by ASHRAE and has been developed for several years. In 2009, ASHRAE released the Load Calculation Applications Manual as the most recent version of their energy calculations. Using an excel worksheet included with the book, the thermal characteristics of the study lounge will be studied and summarized in this part of the report.

Input Data

Below are the general inputs required by the study. Because of the software's design, glazing properties for the initial trial will not include the frit pattern glazing on the east wall. The software is designed to only select one glass for a simulation. The reasons why will be discussed later in this breadth.

Closest Design Location: Baltimore, Maryland

Design: 1% conditions

Indoor environment conditions: 75 degree dry bulb, 50% relative humidity.

Schedules:

Occupancy will follow the normal school year occupancy. Lighting in the space is designed to run off of the building automation system. Equipment is designed as personal computers since this will be the heaviest load entering the space.

Hours	People	Lighting	Equipment
1	0.0	0.1	0.1
2	0.0	0.1	0.1
3	0.0	0.1	0.1

4	0.0	0.1	0.1
5	0.0	0.1	0.1
6	0.0	0.1	0.1
7	0.7	0.1	0.1
8	0.7	0.5	0.3
9	0.7	0.5	0.3
10	0.7	0.5	0.3
11	0.7	0.5	0.3
12	0.9	0.5	0.3
13	0.9	0.5	0.3
14	0.9	0.5	0.3
15	0.9	0.5	0.3
16	0.9	1.0	0.8
17	0.9	1.0	0.8
18	0.9	1.0	0.8
19	0.9	1.0	0.8
20	0.9	1.0	0.8
21	0.5	1.0	0.8
22	0.5	0.5	0.3
23	0.5	0.5	0.3
24	0.5	0.5	0.3

Internal Heat Gains

Total Occupancy (As Designed): 201 people

Sensible Load: 245 Btu/hr, Latent Load: 155 Btu/hr (from text)

Lighting Power Density (As designed): 0.98 W/sq.ft. (No decorative)

Equipment: 0.5 W/sq ft. Assumed based on only carry in equipment being used within the space. Laptop, Ipads, etc.

Fenestration

Because of the way the program is designed, the input parameters of the glass used in the initial design and redesign of the space. A reference glass will be selected based on the actual glasses properties. A benefit of the RTSM method is the account of sun angle. The SHGC is based on sunlight matching the normal of the glass. As the profile angle changes, so does the thermal properties. By selecting a reference glass, the correction factors can be determined for various profile angles.

Glass 1: U-Value = 0.26, SHGC = 0.38, Reference = 25b

Glass 2: U-Value = 0.24, SHGC = 0.37, Reference = 17f

Shading Properties

From Daylighting Study: Transmittance = 9%, Openness = 3%, Reflectance = 11%

During the heavy solar loads, shades will be down in the space, preventing heat from transferring into the space, and changing some gain from convective to radiative. ASHRAE uses an IAC (Interior Attenuation Coefficient) determined from the shades properties. Below is the chart used.

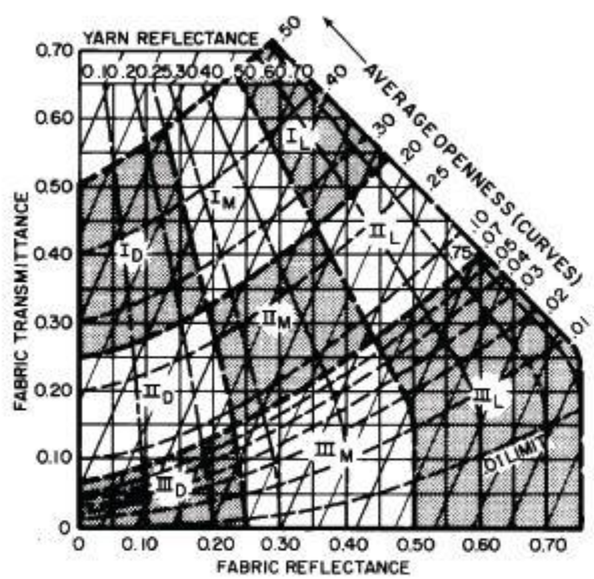


Figure 94: IAC Selection Chart [9]

The shade selected in the daylight study is estimated as a type E shade. Using Table 3.10 of the text, the IAC = 0.63.

Air Changes per Hour

ACH = 60 x Flow Rate Per Person(cfm/person) / Spatial Volume

Space Volume = 47' x 52' x 31' = 75764 ft3

Flow Rate Per Person: 10 cfm/person From ASHRAE 62.1 – 2007 for Classrooms

ACH = (60 x 10 x 201) / 75764 = 1.6

Wall Setup

Along with the SHGC correction, RTSM's other main components are the Conduction Time Series Factors (CTSF) and sol-air temperatures. CTSFs correct for heat buildup in materials long after the source of heating has been removed. The thicker the wall, the slower the heat dissipation and collection will be. Sol-air temperature adjusts convective heat transfer to conductive heat transfer. The sol-air temperature is the calculated temperature at the boundary layer between the outdoor environment and the surface of the wall. By inputting the various layers within glass, the CTSF can be generated. Sol-air will be based off the irradiation data released by ASHRAE based on location and design condition.

Though the wall is primarily glass, there is a 2' spandrel panel around the space. The default spandrel panel was used. The roof and floor were modeled as interior surfaces so they had no impact on the solar gain within the space. This allows for a more in-depth look at the changes in solar gains due to the daylighting redesign.

Results

After running the RTSM program under the conditions above, the following results were obtained. The two parameters measured were Annual Cooling Load and Design Day Solar Load. The annual cooling load metric shows the overall impact of solar gain throughout the year. The design day solar load shows the exact impact of shading, and changing reference glass.

	Design Solar Load (Btu/hr)	Annual Cooling Load (Btu/hr)
Original Glazing	132,879.6	343,391.3
Change in Glazing	126,597.2	337,109.0
With Shades	82,563.9	295,748.0

The implementation of shades reduced the design cooling load by 37.9%. Annual cooling load was also drastically reduced. The overall load will receive savings with the added shades. This program will apply shades at all hours throughout the year so the actual savings is expected to be less than the amount shown above. Changing glazing does not have the impact that adding another barrier to the wall will.

Electrical Redesign

Introduction

This report covered the lighting redesign of five spaces within Towson's West Village Commons. Those five spaces include the lobby and grand stair, student lounge, HRL suite, Multi-purpose space and Roof Terrace. Each is a well-defined space because of its important purpose in the building. Each space was designed with the overall idea of what would a student like to see. The key theme to the building is the transparency of the building and building off the outdoor themes of the original design. Lighting was achieved primarily through fluorescent and LED fixtures. The use of LEDs played an important role in acting as the new "green" space on campus.

Existing Panelboards

Table 25: Existing Panelboards

PANELBOARDS								
Panel Tag	Voltage	System	Grand Stair	Study Lounge	HRL Suite	MP Room	Terrace
LP4	480Y/277V, 3P, 4W	N		X	X		X
EB	480Y/277V, 3P, 4W	E	X	X	X	X	X
LP1	480Y/277V, 3P, 4W	N	X	X			
LP2	480Y/277V, 3P, 4W	N	X	X			
DM4	480Y/277V, 3P, 4W	N				X	
DM4A	208Y/120V, 3P, 4W	N				X	

WIRING PANEL SCHEDULE LP4 (LTG CONTROL PANELBOARD)

277/480 VOLTS | 3 PHASE 4 WIRE | 400 AMP MAINS | SURFACE MOUNTED

CIR-CUIT	POLE	DESCRIPTION	WIRE/ CONDUIT	BREAKER POLE	BREAKER AMP	KVA / %%C A%%C		B%%C		C%%C		CIR-CUIT	POLE	DESCRIPTION	WIRE/ CONDUIT	BREAKER POLE	BREAKER AMP
1	1	+ LTG - PRE-FUNCTION 401	#10-3/4"C	1	20+	0.3	1.1					2	2	+ LTG - LOBBY 301	#10/-3/4"C	1	20+
3	3	+ LTG - CORRIDOR 402	#10-3/4"C	1	20+			0.2	0.2			4	4	+ LTG - CASUAL SEATING 302	#10/-3/4"C	1	20+
5	5	LTG - LEVEL 4 RESTROOMS	#10-3/4"C	1	20					0.4	0.2	6	6	+ LTG - CORRIDOR 304	#10/-3/4"C	1	20+
7	7	+ LTG - LOBBY 400	#10-3/4"C	1	20+	1.2	0.4					8	8	LTG - LEVEL 3 RESTROOMS	#10/-3/4"C	1	20
9	9	+ LTG - SERVICE CORRIDOR 412	#10-3/4"C	1	20+			0.3	0.6			10	10	LTG - IT, CUSTODIAL, STOR - LVL	#10/-3/4"C	1	20
11	11	LTG - PLATING KITCHEN 409	#10-3/4"C	1	20					1.1	0.5	12	12	LTG - EVENTS SUITE - LVL 3	#10/-3/4"C	1	20
13	13	+ LTG - CORRIDOR 410	#10-3/4"C	1	20+	0.9	0.1					14	14	+ LTG - LVL 3 EXTERIOR	#10/-3/4"C	1	20+
	15	SPARE		1	20				1.0			16	16	+ LTG - CORRIDOR 314	#10/-3/4"C	1	20+
	17	+ SPARE		1	20+						1.5	18	18	LTG - MEETING RMS - LVL 3	#10/-3/4"C	1	20
	19	+ SPARE		1	20+		0.3					20	20	+ LTG - CORRIDOR 313	#10/-3/4"C	1	20+
	21	+ SPARE		1	20+				2.0			22	22	LTG - LVL 3 OFFICE SUITE	#10/-3/4"C	1	20
	23	+ SPARE		1	20+						2.3	24	24	LTG - LVL 3 OFFICE SUITE	#10/-3/4"C	1	20
	25	SPARE		1	20		1.0					26	26	LTG - EXERCISE 337,343	#10/-3/4"C	1	20
	27	SPARE		1	20								28	**SPARE**		1	20+
	29	SPARE		1	20						1.2	30	30	+ EXTERIOR LTG	#10/-3/4"C	1	20+
	31	SPARE		1	20		2.6					32	32	DIMMING PANEL DM4	4 #6 +	3	60
	33	SPARE		1	20				2.0			-	34		#10G -		
	35	SPARE		1	20						2.0	-	36		1"C		
37	37	PANEL RP4	3 #350 +	3	300	58.6	-					38	38	TVSS	4 #6 +	3	30
-	39	(SUB-FEED CIRCUIT BREAKER)	#4G -					53.1	-			-	40		#6G -		
-	41		3"C							50.4	-	-	42		1"C		
						61.0	5.5	53.6	5.8	51.9	7.7						
						66.5		59.4		59.6							

CONNECTED LOAD = 185.5 KVA MAIN BREAKER 400 AMPS

DEMAND LOAD = 128.5 KVA + PROVIDE LOW-VOLTAGE CONTROLLED, ELECTRICALLY OPERATED CIRCUIT BREAK

** PROVIDE SUB-FEED CIRCUIT BREAKER

MIN AIC RATING = 14,000 AMPS SYMMETRICAL LOCATION ELECTRICAL 409A

Figure 95: LP4 Panelboard

WIRING PANEL SCHEDULE EB (LIFE SAFETY PANELBOARD) (LTG CONTROL PANELBOARD)

277/480 VOLTS | 3 PHASE 4 WIRE | 400 AMP MAINS | SURFACE MOUNTED

CIR-CUIT	POLE	DESCRIPTION	WIRE/ CONDUIT	BREAKER POLE	BREAKER AMP	KVA / %%C A%%C		B%%C		C%%C		CIR-CUIT	POLE	DESCRIPTION	WIRE/ CONDUIT	BREAKER POLE	BREAKER AMP
1	1	LTG - STAIR 1	#10-3/4"C	1	20	1.2	1.8					2	2	+ EXT LTG - BUILDING PERIMETE	#10-3/4"C	1	20+
	3	**SPARE**		1	20				**3.2**			**4**	4	**+ EXTERIOR LTG**	**#4-1"C**	1	20+
	5	SPARE		1	20						**0.7**	**6**	6	**+ LTG - LEVEL 0**	**#10-3/4"C**	1	20+
7	7	LTG - LEVEL 1	#10-3/4:C	1	20	0.5							8	+ SPARE		1	20+
9	9	LTG - LEVEL 2	#10-3/4:C	1	20			0.7					10	+ SPARE		1	20+
11	11	LTG - LEVEL 3	#10-3/4:C	1	20					0.7			12	+ SPARE		1	20+
13	13	LTG - LEVEL 3	#10-3/4:C	1	20	1.6							14	+ SPARE		1	20+
15	15	LTG - LEVEL 4	#10-3/4:C	1	20			1.0	0.2			16	16	EXIT SIGNS - LEVEL 0	#10-3/4"C	1	20
17	17	LTG - LEVEL 4	#10-3/4:C	1	20					1.2	0.5	18	18	EXIT SIGNS - LEVEL 1	#10-3/4"C	1	20
19	19	LTG - STAIR 2	#10-3/4:C	1	20	0.7	0.5					20	20	EXIT SIGNS - LEVEL 2	#10-3/4"C	1	20
	21	SPARE		1	20				0.5			22	22	EXIT SIGNS - LEVEL 3	#10-3/4"C	1	20
	23	SPARE		1	20						0.5	24	24	EXIT SIGNS - LEVEL 4	#10-3/4"C	1	20
	25	SPARE		1	20								26	SPARE		1	20
	27	SPARE		1	20								28	SPARE		1	20
	29	SPARE		1	20								30	SPARE		1	20
	31	SPARE		1	20								32	SPARE		1	20
	33	SPARE		1	20								34	SPARE		1	20
	35			1	20								36	SPARE		1	20
37	37	PANEL EPB (VIA XFMR TEPB)	3 #10 +	3	30	0.8	-					38	38	TVSS	4 #6 +	3	30
-	39		#10G-					1.0	-			-	40		#6G -		
-	41		3/4"C							1.0	-	-	42		1"C		
						4.8	2.3	2.7	3.9	2.9	1.7						
						7.1		6.6		4.6							

CONNECTED LOAD = 18.3 KVA MAIN BREAKER 100 AMPS

DEMAND LOAD = 17.8 KVA + PROVIDE LOW-VOLTAGE CONTROLLED, ELECTRICALLY OPERATED CIRCUIT BREAK

MIN AIC RATING = 14,000 AMPS SYMMETRICAL LOCATION ELECTRICAL 003

Figure 96: EB Panelboard

WIRING PANEL SCHEDULE LP1 (LTG CONTROL PANELBOARD)

277/480 VOLTS | 3 PHASE 4 WIRE | 125 AMP MAINS | SURFACE MOUNTED

CIR-CUIT	POLE	DESCRIPTION	WIRE/ CONDUIT	BREAKER POLE	BREAKER AMP	KVA / %%C A%%C		B%%C		C%%C		CIR-CUIT	POLE	DESCRIPTION	WIRE/ CONDUIT	BREAKER POLE	BREAKER AMP
1	1	LTG - LEVEL 1 BACK OF HOUSE	#10-3/4"C	1	20	1.9	0.3					2	2	+ LTG (ZONE D)	#10-3/4"C	1	20+
3	3	+ LTG - CORRIDOR 104	#10-3/4"C	1	20+			0.2					4	+ SPARE		1	20+
5	5	LTG - REST RMS & SHWR RMS	#10-3/4"C	1	20					0.8			6	+ SPARE		1	20+
7	7	LTG - KITCHEN & BACK OF HOUS	#10-3/4"C	1	20	0.5							8	+ SPARE		1	20+
9	9	+ LTG - LOBBY	#10-3/4"C	1	20+			0.6					10	+ SPARE		1	20+
11	11	+ LTG - LOBBY, CASUAL SEATIN	#10-3/4"C	1	20+					0.7			12	+ SPARE		1	20+
13	13	+ LTG - RETAIL SEATING 128	#10-3/4"C	1	20+	0.4							14	SPARE		1	20
	15	SPARE		1	20								16	SPARE		1	20
17	17	+ LTG - ZONE A (LEVELS 1-4)	#10-3/4"C	1	20+					2.2			18	SPARE		1	20
	19	SPARE		1	20								20	SPARE		1	20
	21	SPARE		1	20								22	SPARE		1	20
	23	SPARE		1	20								24	SPARE		1	20
	25	SPARE		1	20		-					26	26	TVSS	4 #6 +	3	30
	27	SPARE		1	20				-			-	28		#6G -		
	29	SPARE		1	20						-	-	30		1"C.		
						2.8	0.3	0.8	0.0	3.7	0.0						
		CONNECTED LOAD =	7.6	KVA		3.1		0.8		3.7				MAIN BREAKER	125	AMPS	

DEMAND LOAD = 7.6 KVA

+ PROVIDE LOW-VOLTAGE CONTROLLED, ELECTRICALLY OPERATED CIRCUIT BREAK

MIN AIC RATING = 35,000 AMPS SYMMETRICAL

LOCATION NEAR ELEV. 122

Figure 97: LP1 Panelboard

WIRING PANEL SCHEDULE LP2 (LTG CONTROL PANELBOARD)

277/480 VOLTS | 3 PHASE 4 WIRE | 125 AMP MAINS | SURFACE MOUNTED

CIR-CUIT	POLE	DESCRIPTION	WIRE/ CONDUIT	BREAKER POLE	BREAKER AMP	KVA / %%C A%%C		B%%C		C%%C		CIR-CUIT	POLE	DESCRIPTION	WIRE/ CONDUIT	BREAKER POLE	BREAKER AMP
1	1	TRACK/WALL WASH - LOBBIES	#10-3/4"C	1	20	2.1						2	2	+ SPARE		1	20+
3	3	+ LTG - LEVEL 2 DIMMED DINING	#10-3/4"C	1	20+			1.1				4	4	+ SPARE		1	20+
5	5	LTG - LEVEL 2 KITCHEN AREA	#10-3/4"C	1	20					2.1		6	6	+ SPARE		1	20+
7	7	+ LTG - LEVEL 2 SERVING AREA	#10-3/4"C	1	20+	0.8						8	8	+ SPARE		1	20+
9	9	+ LTG - LEVEL 2 LOBBY, RESTRM	#10-3/4"C	1	20+			1.5				10	10	+ SPARE		1	20+
11	11	+ LTG - LEVEL 2 KITCHEN 204, 2(	#10-3/4"C	1	20+					1.4		12	12	+ SPARE		1	20+
	13	SPARE		1	20							14	14	SPARE		1	20
	15	SPARE		1	20							16	16	SPARE		1	20
	17	SPARE		1	20							18	18	SPARE		1	20
	19	SPARE		1	20							20	20	SPARE		1	20
	21	SPARE		1	20							22	22	SPARE		1	20
	23	SPARE		1	20							24	24	SPARE		1	20
	25	SPARE		1	20		-					26	26	TVSS	4 #6 +	3	30
	27	SPARE		1	20				-			-	28		#6G -		
	29	SPARE		1	20						-	-	30		1"C.		
						2.9	0.0	2.6	0.0	3.5	0.0						
		CONNECTED LOAD =	9.0	KVA		2.9		2.6		3.5				MAIN BREAKER	125	AMPS	

DEMAND LOAD = 9.0 KVA

+ PROVIDE LOW-VOLTAGE CONTROLLED, ELECTRICALLY OPERATED CIRCUIT BREAK

MIN AIC RATING = 35,000 AMPS SYMMETRICAL

LOCATION DRY STORAGE 207

Figure 98: LP2 Panelboard

WIRING SCHEDULE DIMMING PANEL DM4 (FOR MULTIPURPOSE ROOM 411)

277/480 VOLTS | 3 PHASE 4 WIRE | 80 AMPERES MLO | SURFACE MOUNTED

CIRCUIT #	ZONE	ZONE/CIRCUIT DESCRIPTION	WIRE/CONDUIT (SEE NOTE 2)	LOAD TYPE	BREAKER POLE	BREAKER AMP	LOAD (KVA) A Ø	LOAD (KVA) B Ø	LOAD (KVA) C Ø
DM4-1	1	TYPE D FIXTURES (A)	2 #12 + #12G - 3/4"C.	T5 FLUORESCENT - DIMMING	1	20	1.0		
DM4-2	2	TYPE D FIXTURES (A)	2 #12 + #12G - 3/4"C.	T5 FLUORESCENT - DIMMING	1	20		1.0	
DM4-3	3	TYPE D FIXTURES (B)	2 #12 + #12G - 3/4"C.	T5 FLUORESCENT - DIMMING	1	20			1.0
DM4-4	4	TYPE D FIXTURES (B)	2 #12 + #12G - 3/4"C.	T5 FLUORESCENT - DIMMING	1	20	1.0		
DM4-5	5	TYPE D FIXTURES (C)	2 #12 + #12G - 3/4"C.	T5 FLUORESCENT - DIMMING	1	20		1.0	
DM4-6	6	TYPE D FIXTURES (C)]	2 #12 + #12G - 3/4"C.	T5 FLUORESCENT - DIMMING	1	20			1.0
DM4-7	7	EMERGENCY TRANSFER RELAYS	2 #12 + #12G - 3/4"C.	UNSWITCHED CIRCUIT (SEE NOTE 2)	1	20	0.6		
	8	SPARE			1	20			
	9	SPARE			1	20			
	10	SPARE			1	20			
	11	SPARE			1	20			
	12	SPARE			1	20			
							2.6	2.0	2.0

CONNECTED LOAD = 6.6 KVA

MIN AIC RATING = 14,000 AMPS SYMMETRICAL

DIMMING PANEL NOTES:

1. PROVIDE DEDICATED NEUTRAL CONDUCTOR FOR EACH DIMMER CIRCUIT.
2. PROVIDE UNSWITCHED CIRCUIT TO EMERGENCY LIGHTING TRANSFER RELAYS IN MULTIPURPOSE 411

WIRING SCHEDULE DIMMING PANEL DM4A (FOR MULTIPURPOSE ROOM 411)

120/208 VOLTS | 3 PHASE 4 WIRE | 80 AMPERES MLO | SURFACE MOUNTED

CIRCUIT #	ZONE	ZONE/CIRCUIT DESCRIPTION	WIRE/CONDUIT (SEE NOTE 2)	LOAD TYPE	BREAKER POLE	BREAKER AMP	LOAD (KVA) A Ø	LOAD (KVA) B Ø	LOAD (KVA) C Ø
DM4A-13	13	TYPE ST TRACK LIGHTING (A)	2 #12 + #12G - 3/4"C.	TRACK LIGHTING - DIMMING	1	20	0.7		
DM4A-14	14	TYPE ST TRACK LIGHTING (A)	2 #12 + #12G - 3/4"C.	TRACK LIGHTING - DIMMING	1	20		0.7	
DM4A-15	15	TYPE ST TRACK LIGHTING (B)	2 #12 + #12G - 3/4"C.	TRACK LIGHTING - DIMMING	1	20			0.7
DM4A-16	16	TYPE ST TRACK LIGHTING (B)	2 #12 + #12G - 3/4"C.	TRACK LIGHTING - DIMMING	1	20	0.7		
DM4A-17	17	TYPE ST TRACK LIGHTING (C)	2 #12 + #12G - 3/4"C.	TRACK LIGHTING - DIMMING	1	20		0.7	
DM4A-18	18	TYPE ST TRACK LIGHTING (C)	2 #12 + #12G - 3/4"C.	TRACK LIGHTING - DIMMING	1	20			0.7
	19	SPARE			1	20			
	20	SPARE			1	20			
	21	SPARE			1	20			
	22	SPARE			1	20			
	23	SPARE			1	20			
	24	SPARE			1	20			
							1.4	1.4	1.4

CONNECTED LOAD = 4.2 KVA

MIN AIC RATING = 10,000 AMPS SYMMETRICAL

DIMMING PANEL NOTES:

1. PROVIDE DEDICATED NEUTRAL CONDUCTOR FOR EACH DIMMER CIRCUIT.

Figure 99: DM4 and DM4a Dimming Panel

Revised Panel Layouts

Panel DM4A was removed since all the loads in the Multi-Purpose Room were removed from the space. With the new decorative lighting in the lobby and study lounge, an additional panel will be needed at 208Y/120V. This can be supplied by the distribution panel DPB. The new lighting panel will be designated LDP.

PANELBOARD SIZING WORKSHEET											
Panel Tag------------------------->					LDP	Panel Location:			Electrical Room 003		
Nominal Phase to Neutral Voltage------->					120	Phase:			3		
Nominal Phase to Phase Voltage-------->					208	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	Lighting		Lobby	1120	w	0.90	1120	1244		
2	A	Lighting		Lobby	1120	w	1.00	1120	1120		
3	B	Lighting		Lobby - 2nd flo	1120	w	0.90	1120	1244		
4	B	Lighting		Lounge 302	1120	w	1.00	1120	1120		
5	C	Spare			13	A	1.00	1560	1560		
6	C	Lighting		Lounge 302	9.52	A	0.90	1028	1142		
7	A	Spare			13	w	1.00	13	13		
8	A	Spare			13	A	1.00	1560	1560		
9	B	Spare			13	A	1.00	1560	1560		
10	B	Spare			13	A	1.00	1560	1560		
11	C	Spare			13	A	1.00	1560	1560		
12	C	Spare			13	A	1.00	1560	1560		
13	A	Space			10	w		10	13		
14	A	Space			10	w		10	13		
15	B	Space			10	w		10	13		
16	B	Space			10	w		10	13		
17	C	Space			10	w		10	13		
18	C	Space			10	w		10	13		
19	A	Space			10	w		10	13		
20	A	Space			10	w		10	13		
21	B	Space			10	w		10	13		
22	B	Space			10	w		10	13		
23	C	Space			10	w		10	13		
24	C	Space			10	w		10	13		
25	A	Space			10	w		10	13		
26	A	Space			10	w		10	13		
27	B	Space			10	w		10	13		
28	B	Space			10	w		10	13		
29	C	Space			10	w		10	13		
30	C	Space			10	w		10	13		
31	A				0	w		0	0		
32	A				0	w		0	0		
33	B				0	w		0	0		
34	B				0	w		0	0		
35	C				0	w		0	0		
36	C				0	w		0	0		
37	A				0	w		0	0		
38	A				0	w		0	0		
39	B				0	w		0	0		
40	B				0	w		0	0		
41	C				0	w		0	0		
42	C				0	w		0	0		
PANEL TOTAL								15.1	15.5	Amps=	43.0
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					3.9	4.0	26%	33.4
PHASE TOTAL			B					5.4	5.6	36%	46.3
PHASE TOTAL			C					5.8	5.9	38%	49.1
LOAD CATAGORIES				Connected			Demand				Ver. 104
				kW	kVA	DF	kW	kVA	PF		
1	receptacles			0.0	0.0		0.0	0.0			
2	computers			0.0	0.0		0.0	0.0			
3	fluorescent lighting			0.0	0.0	1.25	0.0	0.0			
4	HID lighting			0.0	0.0		0.0	0.0			
5	incandescent lighting			0.0	0.0		0.0	0.0			
6	HVAC fans			0.0	0.0		0.0	0.0			
7	heating			0.0	0.0		0.0	0.0			
8	kitchen equipment			0.0	0.0		0.0	0.0			
9	unassigned			15.1	15.5		15.1	15.5	0.97		
Total Demand Loads							15.1	15.5			
Spare Capacity				20%			3.0	3.1			
Total Design Loads							18.1	18.6	0.97	Amps=	51.6

Default Power Factor =	0.80
Default Demand Factor =	100 %

Figure 100: Panelboard LDP Worksheet

PANELBOARD SCHEDULE

VOLTAGE:	208Y/120V,3PH,4W	PANEL TAG:	LDP	MIN. C/B AIC:	10K
SIZE/TYPE BUS:		PANEL LOCATION:	Electrical Room 003	OPTIONS:	PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN:		PANEL MOUNTING:	SURFACE		FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Lobby	1120	20A/1P	1	*			2	20A/1P	1120	Lobby - 2nd floor	Lighting
Lighting	Lobby	1120	20A/1P	3		*		4	20A/1P	1120	Lounge 302	Lighting
Spare	0	1560	20A/1P	5			*	6	20A/1P	1028	Lounge 302	Lighting
Spare	0	13	20A/1P	7	*			8	20A/1P	1560		Spare
Spare		1560	20A/1P	9		*		10	20A/1P	1560	0	Spare
Spare	0	1560	20A/1P	11			*	12	20A/1P	1560		Spare
Space		10	20A/1P	13	*			14	20A/1P	10		Space
Space		10	20A/1P	15		*		16	20A/1P	10		Space
Space		10	20A/1P	17			*	18	20A/1P	10		Space
Space		10	20A/1P	19	*			20	20A/1P	10		Space
Space		10	20A/1P	21		*		22	20A/1P	10		Space
Space		10	20A/1P	23			*	24	20A/1P	10		Space
Space		10	20A/1P	25	*			26	20A/1P	10		Space
Space		10	20A/1P	27		*		28	20A/1P	10		Space
Space		10	20A/1P	29			*	30	20A/1P	10		Space
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A Ph.	3.87	TOTAL DESIGN LOAD (KW)	18.07
CONNECTED LOAD (KW) - B Ph.	5.42	POWER FACTOR	0.97
CONNECTED LOAD (KW) - C Ph.	5.77	TOTAL DESIGN LOAD (AMPS)	52

Figure 101: Panelboard LDP

Panelboard			
	Tag		LDP
	Voltage System		208Y/120V, 3PH, 4W
	Calculated Design Load (kW)		18.07
	Calculated Power Factor		0.97
	Calculated Design Load (kVA)		18.6
	Calculated Design Load (A)		65
Feeder			
	Feeder Protection Size		70
	Number of Sets		1
	Wire Size		
		Phase	#4
		Neutral	#4
		Ground	#8
	Wire Area (table 5)		
		Each Phase	0.0824
		Total – All phases	0.2472
		Neutral	0.0824
		Ground	0.0366
		Total – All Wires	0.3662
	Minimum Conduit Area (above * 2.5)		0.9155
	Conduit Size (Table 4)		1.25"
	Conduit Size (Table C.1)		1.5"
	Feeder Length		20'-0"
	Final Voltage Drop (V)		0.6
	Final Voltage Drop (%)		1%
	Was feeder re-sized?		Yes

Figure 102: Panelboard LDP Data

PANELBOARD SIZING WORKSHEET											
Panel Tag------------------------->					EB	Panel Location:			Electrical Room 003		
Nominal Phase to Neutral Voltage------->					277	Phase:			3		
Nominal Phase to Phase Voltage-------->					480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	Lighting	3	Stair 1	1	KVA	1.00	1000	1000		
2	A	Lighting	3	Exterior Perimeter	1.8	KVA	1.00	1800	1800		
3	B	Spare			13	A	1.00	3601	3601		
4	B	Lighting	3	Exterior	3.2	KVA	1.00	3200	3200		
5	C	Spare			13	A	1.00	3601	3601		
6	C	Lighting	3	Level 0	0.7	KVA	1.00	700	700		
7	A	Lighting	3	Level 1	0.5	KVA	1.00	500	500		
8	A	Spare			13	A	1.00	3601	3601		
9	B	Lighting	3	Level 2	0.7	KVA	1.00	700	700		
10	B	Spare			13	A	1.00	3601	3601		
11	C	Lighting	3	Level 3	0.78	A	1.00	216	216		
12	C	Spare			13	A	1.00	3601	3601		
13	A	Lighting	3	Level 3	2	A	1.00	554	554		
14	A	Spare			13	A	1.00	3601	3601		
15	B	Lighting	3	Level 4	1	KVA	1.00	1000	1000		
16	B	Lighting	3	Exit - Level 0	0.2	KVA	1.00	200	200		
17	C	Lighting	3	Level 4	2.88	a	1.00	798	798		
18	C	Lighting	3	Exit - Level 1	0.5	KVA	1.00	500	500		
19	A	Lighting	3	Stair 2	0.7	KVA	1.00	700	700		
20	A	Lighting	3	Exit - Level 2	0.5	KVA	1.00	500	500		
21	B	Spare			13	A	1.00	3601	3601		
22	B	Lighting	3	Exit - Level 3	0.5	KVA	1.00	500	500		
23	C	Spare			13	A	1.00	3601	3601		
24	C	Lighting	3	Exit - Level 4	0.5	KVA	1.00	500	500		
25	A	Spare			13	A	1.00	3601	3601		
26	A	Spare			13	A	1.00	3601	3601		
27	B	Spare			13	A	1.00	3601	3601		
28	B	Spare			13	A	1.00	3601	3601		
29	C	Spare			13	A	1.00	3601	3601		
30	C	Spare			13	A	1.00	3601	3601		
31	A	Spare			13	A	1.00	3601	3601		
32	A	Spare			13	A	1.00	3601	3601		
33	B	Spare			13	A	1.00	3601	3601		
34	B	Spare			13	A	1.00	3601	3601		
35	C	Spare			13	A	1.00	3601	3601		
36	C	Spare			13	A	1.00	3601	3601		
37	A	Panel		Panel EPB	0.8	KVA	1.00	800	800		
38	A	TVSS			0	w		0	0		
39	B	Panel		Panel EPB	1	KVA	1.00	1000	1000		
40	B	TVSS			0	w		0	0		
41	C	Panel		Panel EPB	1	KVA	1.00	1000	1000		
42	C	TVSS			0	w		0	0		
PANEL TOTAL								88.2	88.2	Amps=	106.1
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					27.5	27.5	31%	99.1
PHASE TOTAL			B					31.8	31.8	36%	114.8
PHASE TOTAL			C					28.9	28.9	33%	104.4
LOAD CATAGORIES				Connected			Demand				Ver. 104
				kW	kVA	DF	kW	kVA	PF		
1		receptacles		0.0	0.0	1.00	0.0	0.0			
2		computers		0.0	0.0	1.00	0.0	0.0			
3		fluorescent lighting		13.4	13.4	1.25	16.7	16.7	1.00		
4		HID lighting		0.0	0.0	1.00	0.0	0.0			
5		incandescent lighting		0.0	0.0	1.00	0.0	0.0			
6		HVAC fans		0.0	0.0	1.00	0.0	0.0			
7		heating		0.0	0.0	1.00	0.0	0.0			
8		kitchen equipment		0.0	0.0	1.00	0.0	0.0			
9		unassigned		74.8	74.8	1.00	74.8	74.8	1.00		
Total Demand Loads							91.5	91.5			
Spare Capacity				20%			18.3	18.3			
Total Design Loads							109.8	109.8	1.00	Amps=	132.2

Default Power Factor =	0.80
Default Demand Factor =	100 %

Figure 103: Panelboard EB Worksheet

VOLTAGE:	480Y/277VV,3PH,4W	PANEL TAG:	EB	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	225A	PANEL LOCATION:	Electrical Room 003	OPTIONS:	PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN:	175A/3P C/B	PANEL MOUNTING:	SURFACE		FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Stair 1	1000	20A/1P	1	*			2	20A/1P	1800	Exterior Perimete	Lighting
Spare		3601	20A/1P	3		*		4	20A/1P	3200	Exterior	Lighting
Spare		3601	20A/1P	5			*	6	20A/1P	700	Level 0	Lighting
Lighting	Level 1	500	20A/1P	7	*			8	20A/1P	3601		Spare
Lighting	Level 2	700	20A/1P	9		*		10	20A/1P	3601		Spare
Lighting	Level 3	216	20A/1P	11			*	12	20A/1P	3601		Spare
Lighting	Level 3	554	20A/1P	13	*			14	20A/1P	3601		Spare
Lighting	Level 4	1000	20A/1P	15		*		16	20A/1P	200	Exit - Level 0	Lighting
Lighting	Level 4	798	20A/1P	17			*	18	20A/1P	500	Exit - Level 1	Lighting
Lighting	Stair 2	700	20A/1P	19	*			20	20A/1P	500	Exit - Level 2	Lighting
Spare		3601	20A/1P	21		*		22	20A/1P	500	Exit - Level 3	Lighting
Spare		3601	20A/1P	23			*	24	20A/1P	500	Exit - Level 4	Lighting
Spare		3601	20A/1P	25	*			26	20A/1P	3601		Spare
Spare		3601	20A/1P	27		*		28	20A/1P	3601		Spare
Spare		3601	20A/1P	29			*	30	20A/1P	3601		Spare
Spare		3601	20A/1P	31	*			32	20A/1P	3601		Spare
Spare		3601	20A/1P	33		*		34	20A/1P	3601		Spare
Spare		3601	20A/1P	35			*	36	20A/1P	3601		Spare
Panel	Panel EPB	800	20A/1P	37	*			38	20A/1P	0		TVSS
Panel	Panel EPB	1000	20A/1P	39		*		40	20A/1P	0		TVSS
Panel	Panel EPB	1000	20A/1P	41			*	42	20A/1P	0		TVSS

CONNECTED LOAD (KW) - A Ph.	27.46	TOTAL DESIGN LOAD (KW)	109.84
CONNECTED LOAD (KW) - B Ph.	31.81	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C Ph.	28.92	TOTAL DESIGN LOAD (AMPS)	132

Figure 104: Panelboard EB

Panelboard	
Tag	EB
Voltage System	480Y/277V, 3PH, 4W
Calculated Design Load (kW)	109.84
Calculated Power Factor	1
Calculated Design Load (kVA)	109.84
Calculated Design Load (A)	132
Feeder	
Feeder Protection Size	175
Number of Sets	1
Wire Size	
Phase	#2/0
Neutral	#2/0
Ground	#4
Wire Area (table 5)	
Each Phase	0.2223
Total – All phases	0.6669
Neutral	0.2223
Ground	0.0824
Total – All Wires	0.9716
Minimum Conduit Area (above * 2.5)	2.429
Conduit Size (Table 4)	2"
Conduit Size (Table C.1)	2"
Feeder Length	5'-0"
Final Voltage Drop (V)	0.1
Final Voltage Drop (%)	0
Was feeder re-sized?	Yes

Figure 105: Panelboard EB Data

PANELBOARD SIZING WORKSHEET											
Panel Tag------------------------->					DM4	Panel Location:			Electrical Room 409		
Nominal Phase to Neutral Voltage------->					277	Phase:			3		
Nominal Phase to Phase Voltage-------->					480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	Lighting	3	MPR	13.36	a	0.95	3516	3701		
2	A	Lighting	4	MPR	1.26	a	0.95	332	349		
3	B	Lighting	3	MPR	13.36	a	0.95	3516	3701		
4	B	Lighting	4	MPR	1.26	a	0.90	314	349		
5	C	Lighting	3	MPR	13.36	a	0.90	3331	3701		
6	C	Lighitng	4	MPR	1.26	a	0.90	314	349		
7	A	Lighting	3	MPR	1.8	a	1.00	499	499		
8	A	Space			10	a	1.00	2770	2770		
9	B	Spare			13	a	1.00	3601	3601		
10	B	Space			10	a	1.00	2770	2770		
11	C	Spare			13	a	1.00	3601	3601		
12	C	Space			10	a	1.00	2770	2770		
13	A				0	w		0	0		
14	A				0	w		0	0		
15	B				0	w		0	0		
16	B				0	w		0	0		
17	C				0	w		0	0		
18	C				0	w		0	0		
19	A				0	w		0	0		
20	A				0	w		0	0		
21	B				0	w		0	0		
22	B				0	w		0	0		
23	C				0	w		0	0		
24	C				0	w		0	0		
25	A				0	w		0	0		
26	A				0	w		0	0		
27	B				0	w		0	0		
28	B				0	w		0	0		
29	C				0	w		0	0		
30	C				0	w		0	0		
31	A				0	w		0	0		
32	A				0	w		0	0		
33	B				0	w		0	0		
34	B				0	w		0	0		
35	C				0	w		0	0		
36	C				0	w		0	0		
37	A				0	w		0	0		
38	A				0	w		0	0		
39	B				0	w		0	0		
40	B				0	w		0	0		
41	C				0	w		0	0		
42	C				0	w		0	0		
PANEL TOTAL								27.3	28.2	Amps=	33.9
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					7.1	7.3	26%	26.4
PHASE TOTAL			B					10.2	10.4	37%	37.6
PHASE TOTAL			C					10.0	10.4	37%	37.6
LOAD CATAGORIES				Connected			Demand				Ver. 104
				kW	kVA	DF	kW	kVA	PF		
1	receptacles			0.0	0.0		0.0	0.0			
2	computers			0.0	0.0		0.0	0.0			
3	fluorescent lighting			10.9	11.6	1.25	13.6	14.5	0.94		
4	HID lighting			1.0	1.0		1.0	1.0	0.92		
5	incandescent lighting			0.0	0.0		0.0	0.0			
6	HVAC fans			0.0	0.0		0.0	0.0			
7	heating			0.0	0.0		0.0	0.0			
8	kitchen equipment			0.0	0.0		0.0	0.0			
9	unassigned			15.5	15.5		15.5	15.5	1.00		
Total Demand Loads							30.0	31.1			
Spare Capacity				20%			6.0	6.2			
Total Design Loads							36.1	37.3	0.97	Amps=	44.9

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Figure 106: DM4 Panel Worksheet

PANELBOARD SCHEDULE												
VOLTAGE:	480Y/277V,3PH,4W		PANEL TAG:	DM4					MIN. C/B AIC:	10K		
SIZE/TYPE BUS:	80A		PANEL LOCATION:	Electrical Room 409					OPTIONS:	PROVIDE FEED THROUGH LUGS		
SIZE/TYPE MAIN:	80A/3P C/B		PANEL MOUNTING:	SURFACE						FOR PANELBOARD 1L1B		
DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	MPR	3516	20A/1P	1	*			2	20A/1P	332	MPR	Lighting
Lighting	MPR	3516	20A/1P	3		*		4	20A/1P	314	MPR	Lighting
Lighting	MPR	3331	20A/1P	5			*	6	20A/1P	314	MPR	Lighitng
Lighting	MPR	499	20A/1P	7	*			8	20A/1P	2770	0	Space
Spare		3601	20A/1P	9		*		10	20A/1P	2770		Space
Spare		3601	20A/1P	11			*	12	20A/1P	2770		Space
		0	20A/1P	13	*			14	20A/1P	0		
		0	20A/1P	15		*		16	20A/1P	0		
		0	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		
CONNECTED LOAD (KW) - A Ph.		7.12								TOTAL DESIGN LOAD (KW)		36.06
CONNECTED LOAD (KW) - B Ph.		10.20								POWER FACTOR		0.97
CONNECTED LOAD (KW) - C Ph.		10.02								TOTAL DESIGN LOAD (AMPS)		45

Figure 107: Panelboard DM4

Panelboard			
	Tag		DM4
	Voltage System		480Y/277V, 3PH, 4W
	Calculated Design Load (kW)		36.06
	Calculated Power Factor		0.97
	Calculated Design Load (kVA)		37.18
	Calculated Design Load (A)		45
Feeder			
	Feeder Protection Size		80 (Built in to Dimmer Panel)
	Number of Sets		1
	Wire Size		
		Phase	#3
		Neutral	#3
		Ground	#10
	Wire Area (table 5)		
		Each Phase	0.0973
		Total – All phases	0.2919
		Neutral	0.0973
		Ground	0.0366
		Total – All Wires	0.4258
	Minimum Conduit Area (above * 2.5)		1.0645
	Conduit Size (Table 4)		1.25"
	Conduit Size (Table C.1)		1.25"
	Feeder Length		10'
	Final Voltage Drop (V)		0.4
	Final Voltage Drop (%)		0%
	Was feeder re-sized?		Yes

Figure 108: Panelboard DM4 Properties

PANELBOARD SIZING WORKSHEET											
Panel Tag------------------------->					LP4	Panel Location:			Electrical Room 409		
Nominal Phase to Neutral Voltage------->					277	Phase:			3		
Nominal Phase to Phase Voltage-------->					480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	Lighting	3	Pre-Function 401	9.13	KVA	1.00	9130	9130		
2	A	Lighting	3	Lobby 301	1.1	KVA	1.00	1100	1100		
3	B	Lighting	3	Corridor 402	0.2	KVA	1.00	200	200		
4	B	Lighting	3	Casual Seating 302	3.18	A	1.00	881	881		
5	C	Lighting	3	Level 4 Restrooms	0.4	KVA	1.00	400	400		
6	C	Lighting	3	Corridor 304	0.2	KVA	1.00	200	200		
7	A	Lighting	3	Lobby 400	1.2	KVA	1.00	1200	1200		
8	A	Lighting	3	Level 3 Restrooms	0.4	KVA	1.00	400	400		
9	B	Lighting	3	Service Corridor 412	0.3	KVA	1.00	300	300		
10	B	Lighting	3	Custodial - Level 3	0.6	KVA	1.00	600	600		
11	C	Lighting	3	Plating Kitchen 409	1.1	KVA	1.00	1100	1100		
12	C	Lighting	3	Events Suite - Level 3	0.5	KVA	1.00	500	500		
13	A	Lighting	3	Corridor 410	0.9	KVA	1.00	900	900		
14	A	Lighting	3	Level 3 Exterior	500	W	1.00	500	500	2 LED Drivers	
15	B	Spare			13	A	1.00	3601	3601		
16	B	Lighting	3	Corridor 314	1	KVA	1.00	1000	1000		
17	C	Spare			13	A	1.00	3601	3601		
18	C	Lighting	3	Level 3 Meeting Rooms	1.5	KVA	1.00	1500	1500		
19	A	Spare			13	A	1.00	3601	3601		
20	A	Lighting	3	Corridor 313	0.3	KVA	1.00	300	300		
21	B	Spare			13	A	1.00	3601	3601		
22	B	Lighting	3	Level 3 Office Suite	2	KVA	1.00	2000	2000		
23	C	Spare			13	A	1.00	3601	3601		
24	C	Lighting	3	Level 3 Office Suite	4.3	A	1.00	1191	1191		
25	A	Spare			13	A	1.00	3601	3601		
26	A	Lighting	3	Exercise 337, 343	1	KVA	1.00	1000	1000		
27	B	Spare			13	A	1.00	3601	3601		
28	B	Spare			13	A	1.00	3601	3601		
29	C	Spare			13	A	1.00	3601	3601		
30	C	Lighting	3	Exterior Lighting	1.2	KVA	1.00	1200	1200		
31	A	Spare			13	A	1.00	3601	3601		
32	A	Panel		Dimming Panel DM4	26.4	a	1.00	7313	7313		
33	B	Spare			13	A	1.00	3601	3601		
34	B	Panel		Dimming Panel DM4	37.6	a	1.00	10415	10415		
35	C	Spare			13	A	1.00	3601	3601		
36	C	Panel		Dimming Panel DM4	37.6	a	1.00	10415	10415		
37	A	Spare			13	A	1.00	3601	3601		
38	A	TVSS			0	w		0	0		
39	B	Spare			13	A	1.00	3601	3601		
40	B	TVSS			0	w		0	0		
41	C	Spare			13	A	1.00	3601	3601		
42	C	TVSS			0	w		0	0		
PANEL TOTAL								107.8	107.8	Amps=	129.7
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					36.2	36.2	34%	130.9
PHASE TOTAL			B					37.0	37.0	34%	133.6
PHASE TOTAL			C					34.5	34.5	32%	124.6
LOAD CATAGORIES				Connected			Demand				Ver. 104
				kW	kVA	DF	kW	kVA	PF		
1	receptacles			0.0	0.0		0.0	0.0			
2	computers			0.0	0.0		0.0	0.0			
3	fluorescent lighting			25.6	25.6	1.25	32.0	32.0	1.00		
4	HID lighting			0.0	0.0		0.0	0.0			
5	incandescent lighting			0.0	0.0		0.0	0.0			
6	HVAC fans			0.0	0.0		0.0	0.0			
7	heating			0.0	0.0		0.0	0.0			
8	kitchen equipment			0.0	0.0		0.0	0.0			
9	unassigned			82.2	82.2		82.2	82.2	1.00		
Total Demand Loads							114.2	114.2			
Spare Capacity				20%			22.8	22.8			
Total Design Loads							137.0	137.0	1.00	Amps=	164.9

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Figure 109: LP4 Worksheet

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	LP4	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	225A	PANEL LOCATION:	Electrical Room 409	OPTIONS:	PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN:	225A/3P C/B	PANEL MOUNTING:	SURFACE		FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Pre-Function 40	9130	20A/1P	1	*			2	20A/1P	1100	Lobby 301	Lighting
Lighting	Corridor 402	200	20A/1P	3		*		4	20A/1P	881	asual Seating 30	Lighting
Lighting	evel 4 Restroom	400	20A/1P	5			*	6	20A/1P	200	Corridor 304	Lighting
Lighting	Lobby 400	1200	20A/1P	7	*			8	20A/1P	400	Level 3 Restrooms	Lighting
Lighting	ervice Corridor 4	300	20A/1P	9		*		10	20A/1P	600	Custodial - Level 3	Lighting
Lighting	ating Kitchen 40	1100	20A/1P	11			*	12	20A/1P	500	ents Suite - Leve	Lighting
Lighting	Corridor 410	900	20A/1P	13	*			14	20A/1P	500	Level 3 Exterior	Lighting
Spare	0	3601	20A/1P	15		*		16	20A/1P	1000	Corridor 314	Lighting
Spare		3601	20A/1P	17			*	18	20A/1P	1500	el 3 Meeting Roo	Lighting
Spare		3601	20A/1P	19	*			20	20A/1P	300	Corridor 313	Lighting
Spare		3601	20A/1P	21		*		22	20A/1P	2000	evel 3 Office Suit	Lighting
Spare		3601	20A/1P	23			*	24	20A/1P	1191	evel 3 Office Suit	Lighting
Spare		3601	20A/1P	25	*			26	20A/1P	1000	Exercise 337, 34	Lighting
Spare		3601	20A/1P	27		*		28	20A/1P	3601		Spare
Spare		3601	20A/1P	29			*	30	20A/1P	1200	Exterior Lighting	Lighting
Spare		3601	20A/1P	31	*			32	20A/1P	7313	mming Panel DM	Panel
Spare		3601	20A/1P	33		*		34	20A/1P	10415	mming Panel DM	Panel
Spare		3601	20A/1P	35			*	36	20A/1P	10415	mming Panel DM	Panel
Spare		3601	20A/1P	37	*			38	20A/1P	0	0	TVSS
Spare	0	3601	20A/1P	39		*		40	20A/1P	0	0	TVSS
Spare	0	3601	20A/1P	41			*	42	20A/1P	0	0	TVSS

CONNECTED LOAD (KW) - A Ph.	36.25	TOTAL DESIGN LOAD (KW)	136.99
CONNECTED LOAD (KW) - B Ph.	37.00	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C Ph.	34.51	TOTAL DESIGN LOAD (AMPS)	165

Figure 110: Panelboard LP4

Panelboard		
Tag		LP4
Voltage System		480Y/277V, 3PH, 4W
Calculated Design Load (kW)		136.99
Calculated Power Factor		1
Calculated Design Load (kVA)		136.99
Calculated Design Load (A)		165
Feeder		
Feeder Protection Size		225
Number of Sets		1
Wire Size		
	Phase	#4/0
	Neutral	#4/0
	Ground	#6
Wire Area (table 5)		
	Each Phase	0.3237
	Total – All phases	0.9711
	Neutral	0.3237
	Ground	0.0824
	Total – All Wires	1.3772
Minimum Conduit Area (above * 2.5)		3.443
Conduit Size (Table 4)		3"
Conduit Size (Table C.1)		2.5"
Feeder Length		80'
Final Voltage Drop (V)		1.7
Final Voltage Drop (%)		1%
Was feeder re-sized?		Yes

Figure 111: Panelboard LP4 Properties

PANELBOARD SIZING WORKSHEET										
Panel Tag------------------------->				LP2	Panel Location:			Electrical Room 003		
Nominal Phase to Neutral Voltage------->				277	Phase:			3		
Nominal Phase to Phase Voltage-------->				480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	Lighting	3	ll Wash - Lo	8.63	a	1.00	2391	2391	
2	A	Spare			13	a	1.00	3601	3601	
3	B	Lighting	3	evel 2 Dinin	1.1	KVA	1.00	1100	1100	
4	B	Spare			13	a	1.00	3601	3601	
5	C	Lighting	3	evel 2 Kitche	2.1	KVA	1.00	2100	2100	
6	C	Lighting			13	a	1.00	3601	3601	
7	A	Lighting	3	evel 2 Servir	0.8	KVA	1.00	800	800	
8	A	Spare			13	a	1.00	3601	3601	
9	B	Lighting	3	2 Lobby, Res	1.5	KVA	1.00	1500	1500	
10	B	Spare			13	a	1.00	3601	3601	
11	C	Lighting	3	el 2 Kitchen	1.4	KVA	1.00	1400	1400	
12	C	Spare			13	a	1.00	3601	3601	
13	A	Spare			13	a	1.00	3601	3601	
14	A	Spare			13	a	1.00	3601	3601	
15	B	Spare			13	a	1.00	3601	3601	
16	B	Spare			13	a	1.00	3601	3601	
17	C	Spare			13	a	1.00	3601	3601	
18	C	Spare			13	a	1.00	3601	3601	
19	A	Spare			13	a	1.00	3601	3601	
20	A	Spare			13	a	1.00	3601	3601	
21	B	Spare			13	a	1.00	3601	3601	
22	B	Spare			13	a	1.00	3601	3601	
23	C	Spare			13	a	1.00	3601	3601	
24	C	Spare			13	a	1.00	3601	3601	
25	A	Spare			13	a	1.00	3601	3601	
26	A	TVSS			0	w		0	0	
27	B	Spare			13	a	1.00	3601	3601	
28	B	TVSS			0	w		0	0	
29	C	Spare			13	a	1.00	3601	3601	
30	C	TVSS			0	w		0	0	
31	A				0	w		0	0	
32	A				0	w		0	0	
33	B				0	w		0	0	
34	B				0	w		0	0	
35	C				0	w		0	0	
36	C				0	w		0	0	
37	A				0	w		0	0	
38	A				0	w		0	0	
39	B				0	w		0	0	
40	B				0	w		0	0	
41	C				0	w		0	0	
42	C				0	w		0	0	
PANEL TOTAL								84.9	84.9	Amps= 102.2

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					28.4	28.4	33%	102.5
PHASE TOTAL	B					27.8	27.8	33%	100.4
PHASE TOTAL	C					28.7	28.7	34%	103.6

LOAD CATAGORIES			Connected			Demand				Ver. 104
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		9.3	9.3	1.25	11.6	11.6	1.00		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		75.6	75.6		75.6	75.6	1.00		
Total Demand Loads						87.2	87.2			
Spare Capacity			20%			17.4	17.4			
Total Design Loads						104.7	104.7	1.00	Amps=	126.0

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Figure 112: Panelboard LP2 Worksheet

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	LP2	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	175A	PANEL LOCATION:	Electrical Room 003	OPTIONS:	PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN:	225A/3P C/B	PANEL MOUNTING:	SURFACE		FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	/all Wash - Lobl	2391	20A/1P	1	*			2	20A/1P	3601		Spare
Lighting	Level 2 Dining	1100	20A/1P	3		*		4	20A/1P	3601	0	Spare
Lighting	Level 2 Kitchen	2100	20A/1P	5			*	6	20A/1P	3601	0	Lighting
Lighting	Level 2 Serving	800	20A/1P	7	*			8	20A/1P	3601		Spare
Lighting	l 2 Lobby, Resti	1500	20A/1P	9		*		10	20A/1P	3601		Spare
Lighting	evel 2 Kitchen 2(	1400	20A/1P	11			*	12	20A/1P	3601		Spare
Spare		3601	20A/1P	13	*			14	20A/1P	3601		Spare
Spare		3601	20A/1P	15		*		16	20A/1P	3601		Spare
Spare		3601	20A/1P	17			*	18	20A/1P	3601		Spare
Spare		3601	20A/1P	19	*			20	20A/1P	3601		Spare
Spare		3601	20A/1P	21		*		22	20A/1P	3601		Spare
Spare		3601	20A/1P	23			*	24	20A/1P	3601		Spare
Spare		3601	20A/1P	25	*			26	20A/1P	0		TVSS
Spare		3601	20A/1P	27		*		28	20A/1P	0		TVSS
Spare		3601	20A/1P	29			*	30	20A/1P	0		TVSS
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A Ph.	28.40	TOTAL DESIGN LOAD (KW)	104.68
CONNECTED LOAD (KW) - B Ph.	27.81	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C Ph.	28.71	TOTAL DESIGN LOAD (AMPS)	126

Figure 113: Panelboard LP2

Panelboard		
Tag		LP2
Voltage System		480Y/277V, 3PH, 4W
Calculated Design Load (kW)		104.68
Calculated Power Factor		1
Calculated Design Load (kVA)		104.68
Calculated Design Load (A)		126
Feeder		
Feeder Protection Size		175
Number of Sets		1
Wire Size		
	Phase	#2/0
	Neutral	#2/0
	Ground	#8
Wire Area (table 5)		
	Each Phase	0.2223
	Total – All phases	0.6669
	Neutral	0.2223
	Ground	0.0366
	Total – All Wires	0.9258
Minimum Conduit Area (above * 2.5)		2.3145
Conduit Size (Table 4)		2.5"
Conduit Size (Table C.1)		2"
Feeder Length		60'
Final Voltage Drop (V)		1.3
Final Voltage Drop (%)		0%
Was feeder re-sized?		Yes

Figure 114: Panel LP2 Properties

PANELBOARD SIZING WORKSHEET											
Panel Tag------------------------->					LP1	Panel Location:			Electrical Room 003		
Nominal Phase to Neutral Voltage------->					277	Phase:			3		
Nominal Phase to Phase Voltage-------->					480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	Lighting	3	of House Le	1.9	a	1.00	526	526		
2	A	Spare			13	a	1.00	3601	3601		
3	B	Lighting	3	Corridor 104	0.2	KVA	1.00	200	200		
4	B	Spare			13	a	1.00	3601	3601		
5	C	Lighting	3	oms and Sh	0.8	KVA	1.00	800	800		
6	C	Spare			13	a	1.00	3601	3601		
7	A	Lighting	3	and Back o	0.5	KVA	1.00	500	500		
8	A	Spare			13	a	1.00	3601	3601		
9	B	Lighting	3	Lobby	7.49	a	1.00	2075	2075		
10	B	Spare			13	a	1.00	3601	3601		
11	C	Spare			13	a	1.00	3601	3601		
12	C	Spare			13	a	1.00	3601	3601		
13	A	Lighting	3	Retail Space	0.4	KVA	1.00	400	400		
14	A	Spare			13	a	1.00	3601	3601		
15	B	Spare			13	a	1.00	3601	3601		
16	B	Spare			13	a	1.00	3601	3601		
17	C	Spare			13	a	1.00	3601	3601		
18	C	Spare			13	a	1.00	3601	3601		
19	A	Spare			13	a	1.00	3601	3601		
20	A	Spare			13	a	1.00	3601	3601		
21	B	Spare			13	a	1.00	3601	3601		
22	B	Spare			13	a	1.00	3601	3601		
23	C	Spare			13	a	1.00	3601	3601		
24	C	Spare			13	a	1.00	3601	3601		
25	A	Spare			13	a	1.00	3601	3601		
26	A	TVSS		Elec Room	0	w		0	0		
27	B	Spare			13	a	1.00	3601	3601		
28	B	TVSS		Elec Room	0	w		0	0		
29	C	Spare			13	a	1.00	3601	3601		
30	C	TVSS		Elec Room	0	w		0	0		
31	A				0	w		0	0		
32	A				0	w		0	0		
33	B				0	w		0	0		
34	B				0	w		0	0		
35	C				0	w		0	0		
36	C				0	w		0	0		
37	A				0	w		0	0		
38	A				0	w		0	0		
39	B				0	w		0	0		
40	B				0	w		0	0		
41	C				0	w		0	0		
42	C				0	w		0	0		
PANEL TOTAL								80.1	80.1	Amps=	96.4
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					23.0	23.0	29%	83.1
PHASE TOTAL			B					27.5	27.5	34%	99.2
PHASE TOTAL			C					29.6	29.6	37%	106.9
LOAD CATAGORIES				Connected			Demand				Ver. 104
				kW	kVA	DF	kW	kVA	PF		
1	receptacles			0.0	0.0		0.0	0.0			
2	computers			0.0	0.0		0.0	0.0			
3	fluorescent lighting			4.5	4.5	1.25	5.6	5.6	1.00		
4	HID lighting			0.0	0.0		0.0	0.0			
5	incandescent lighting			0.0	0.0		0.0	0.0			
6	HVAC fans			0.0	0.0		0.0	0.0			
7	heating			0.0	0.0		0.0	0.0			
8	kitchen equipment			0.0	0.0		0.0	0.0			
9	unassigned			75.6	75.6		75.6	75.6	1.00		
Total Demand Loads							81.2	81.2			
Spare Capacity				20%			16.2	16.2			
Total Design Loads							97.5	97.5	1.00	Amps=	117.3

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Figure 115: Panel LP1 Worksheet

PANELBOARD SCHEDULE

VOLTAGE: 480Y/270V,3PH,4W	PANEL TAG: LP1	MIN. C/B AIC: 10K	
SIZE/TYPE BUS: 150A	PANEL LOCATION: Electrical Room 003	OPTIONS: PROVIDE FEED THROUGH LUGS	
SIZE/TYPE MAIN: 225A/3P C/B	PANEL MOUNTING: SURFACE	FOR PANELBOARD 1L1B	

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	ck of House Lev	526	20A/1P	1	*			2	20A/1P	3601	0	Spare
Lighting	Corridor 104	200	20A/1P	3		*		4	20A/1P	3601		Spare
Lighting	rooms and Sho	800	20A/1P	5			*	6	20A/1P	3601		Spare
Lighting	n and Back of I	500	20A/1P	7	*			8	20A/1P	3601		Spare
Lighting	Lobby	2075	20A/1P	9		*		10	20A/1P	3601		Spare
Spare	0	3601	20A/1P	11			*	12	20A/1P	3601		Spare
Lighting	Retail Space	400	20A/1P	13	*			14	20A/1P	3601		Spare
Spare		3601	20A/1P	15		*		16	20A/1P	3601		Spare
Spare	0	3601	20A/1P	17			*	18	20A/1P	3601		Spare
Spare		3601	20A/1P	19	*			20	20A/1P	3601		Spare
Spare		3601	20A/1P	21		*		22	20A/1P	3601		Spare
Spare		3601	20A/1P	23			*	24	20A/1P	3601		Spare
Spare		3601	20A/1P	25	*			26	20A/1P	0	Elec Room	TVSS
Spare		3601	20A/1P	27		*		28	20A/1P	0	Elec Room	TVSS
Spare	0	3601	20A/1P	29			*	30	20A/1P	0	Elec Room	TVSS
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A Ph.	23.03	TOTAL DESIGN LOAD (KW)	97.50
CONNECTED LOAD (KW) - B Ph.	27.48	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C Ph.	29.61	TOTAL DESIGN LOAD (AMPS)	117

Figure 116: Panel LP1

Panelboard		
Tag		LP1
Voltage System		480Y/277V, 3PH, 4W
Calculated Design Load (kW)		97.5
Calculated Power Factor		1
Calculated Design Load (kVA)		97.50
Calculated Design Load (A)		117
Feeder		
Feeder Protection Size		150
Number of Sets		1
Wire Size		
	Phase	#1/0
	Neutral	#1/0
	Ground	#6
Wire Area (table 5)		
	Each Phase	0.1885
	Total – All phases	0.5655
	Neutral	0.1885
	Ground	0.0507
	Total – All Wires	0.8047
Minimum Conduit Area (above * 2.5)		2.01175
Conduit Size (Table 4)		2.5"
Conduit Size (Table C.1)		2"
Feeder Length		70'
Final Voltage Drop (V)		1.7
Final Voltage Drop (%)		0%
Was feeder re-sized?		No

Figure 117: Panel LP1 Properties

Protective Device Coordination

The protective device coordination was conducted for a branch on receptacle panel RPB at 20 amps, the protection at the distribution panel DPB at 225A and the switchboard protection at 600A. Coordination is important so that breakers will trip at the right time and isolate the fault rather than delaying or shutting down more equipment then needed.

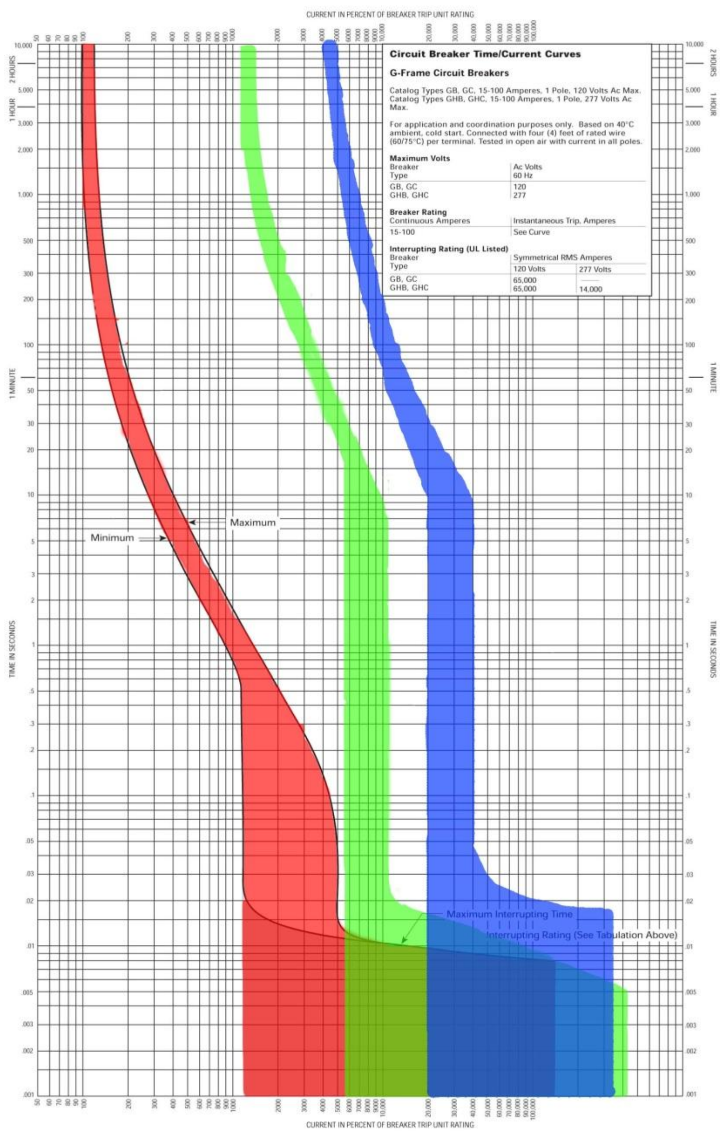


Figure 118: Coordination study

Red = 20A

Green = 225A

Blue = 600A

Short Circuit Analysis

A hand calculation was done for the branch studied above. The per unit method was conducted. Initial short circuit capability is estimated at 100 MVA.

Per Unit Method						
Utiliy Short Circuit	100	MVA				
Base kVA	1500	kVA				
Rated Secondary Current	1805.05	A				
	Length(ft)	**Voltage**	**X**	**R**	**Z**	**Isc (A)**
Utility	--	13200	--	--	0.015	
Transformer	--	480	--	--	0.0575	
Isc at Switchboard			--	--	0.0725	24897.30
Feeder (2 sets 500kcmil)	15	480	0.0014	0.002275	0.00269	
Transformer XDPB	--	208	0.0458	0.02	0.05	
Feeder (4 sets 350kcmil)	15	208	0.0049	0.002397	0.005468	
Isc at DPB			0.052176	0.024673	0.130659	13815.05
Feeder (4/0)	20	208	0.0111	0.017231	0.020494	
Isc at RPB			0.0633	0.041904	0.151153	11941.92

Figure 119: Short Circuit Calculation

SKM Analysis – Electrical Depth 2

Introduction

With designing electrical systems, equipment must be evaluated for normal and stressed conditions. Through the use of SKM Power Tools Software, the projects power distribution system can be modeled. All equipment will be based on products found in the program libraries. Some equipment may be rated to the closest available library product. Square D products were used as the default equipment for the study. Initially, the load flow study will show any voltage changes that could damage or overload equipment. Arc fault and short circuit situations are calculated within the software to check the ratings of the equipment. Additionally with arc faults, clothing requirements are determined based on fault category. A one-line schematic was input into the software. This accounted for changes to the distribution system. Using the DC depth above, the power server load is considered a branch circuit off of a lighting panel. It cannot be not independently modeled in the software. A coordination study was also modeled for the branch of emergency lighting within the building.

Short Circuit Analysis

After using the short circuit analysis, the results were recorded and reported below. When compared to the specified ratings of the panels, various panels exceed the short circuit current. These differences represent the differences between using library based objects instead of specified equipment. For instance, Panel CS-1 is rated at 18 kAIC in the program and reports 10,781 A of fault current. The original specified panel is at 10kAIC, which was not available within the program.

Table 26: SKM Fault Current Results

BUS Name	*Voltage*	*Fault Current (A)*	*Specified Rating (AIC)*
P-CS1	208	10,781	10,000
P-DM4	480	4,653	14,000
P-DM4A	208	1,715	10,000
P-DPB	208	17,925	10,000
P-EB	480	24,375	14,000
P-EPB	208	1,294	10,000
P-KH2	480	21,466	35,000
P-KL2	208	9,251	10,000
P-KL2A	208	9,251	10,000
P-LP1	480	10,987	35,000

BUS Name	*Voltage*	*Fault Current (A)*	*Specified Rating (AIC)*
P-LP2	480	14,908	35,000
P-LP4	480	23,121	14,000
P-LPB	480	27,388	35,000
P-MDB	480	25,595	35,000
P-MP4	480	26,563	14,000
P-MPB	208	1,701	10,000
P-R1	208	7,472	10,000
P-R1A	208	6,207	10,000
P-R1C	208	934	10,000
P-RP2	208	2,218	10,000
P-RP3	208	6,451	10,000
P-RP4	208	6,964	10,000
P-RP4A	208	5,911	10,000
P-RPB	208	15,685	10,000
P-SB	480	24,949	35,000
P-SMB	480	34,443	35,000
P-SP1	208	1,405	10,000
P-SP2	208	1,972	10,000
P-SPB	208	3,218	10,000
P-SWB	480	36,833	35,000
P-VB	480	17,941	35,000
P-VPB	208	1,254	10,000

Coordination Study

The coordination study below is for the emergency lighting panels. This study was conducted from Automatic Transfer Switch 1 to Panel EPB. The resulting overlap between the main circuit breaker for Panel EPB, CB – EPB, and the branch circuit breaker TEPB is due to the change in voltage across the transformer.

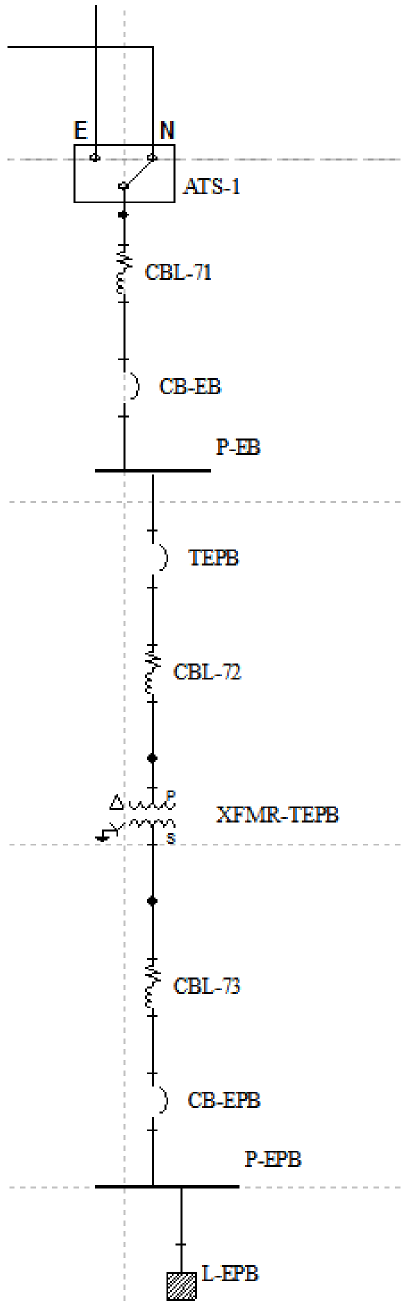


Figure 120: Coordination Branch

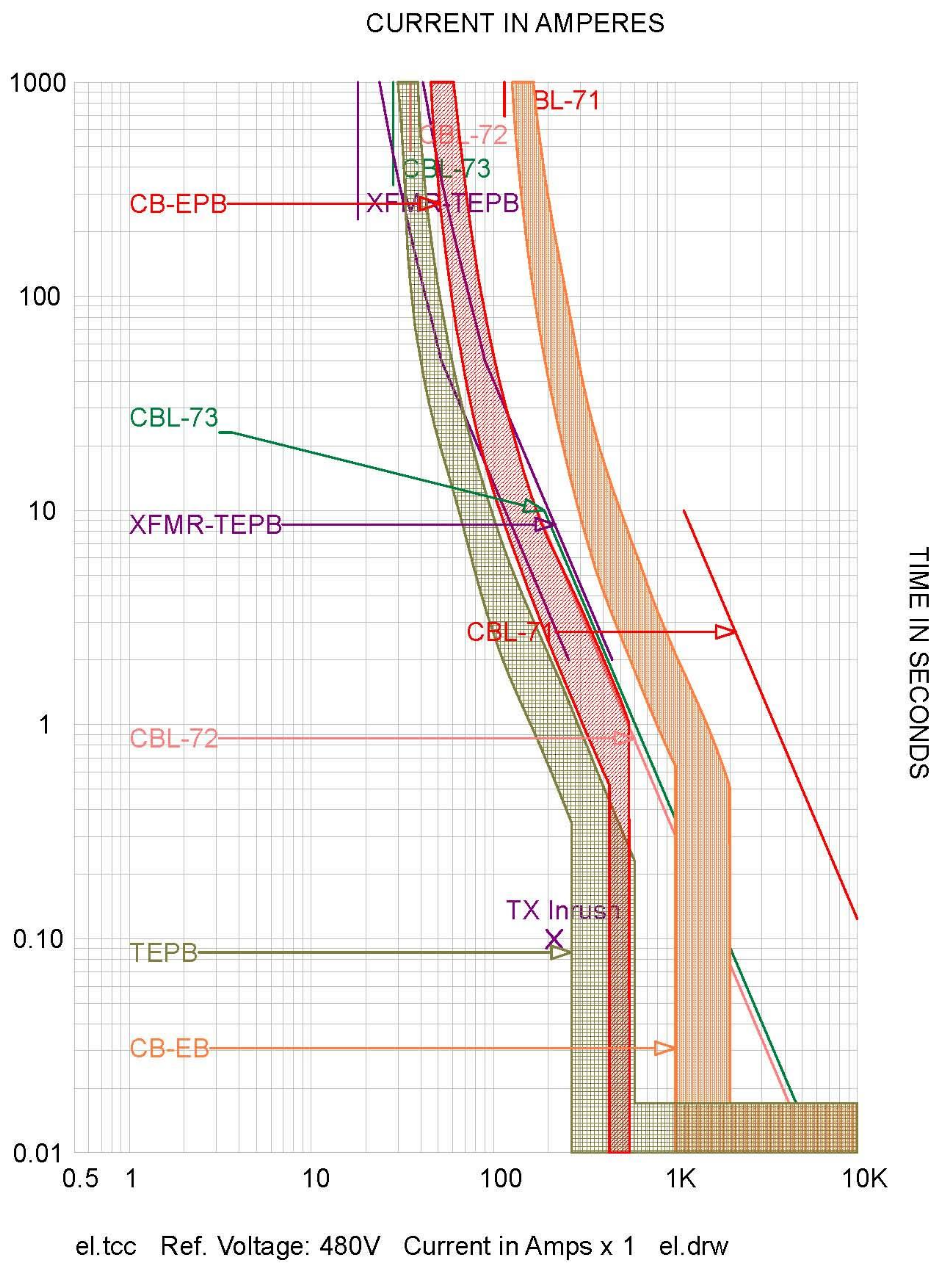


Figure 121: Coordination Study

Load Flow Analysis

A load flow analysis was conducted to analyze voltage drop and overload. There were two wires that were reported as being under overload condition. The analysis concludes that all wire feeder sizes are correct and do not violate over 3% voltage drop. Because of the connections created within the model space, extra busses are created between transformers and cables. This allows for transformer analysis. Transformers studied carry a voltage drop of over 3%.

Table 27: SKM Load Flow Analysis Results

Branch Name	*From*	*To*	*Type*	*VD%*	*Amps*	*kVA*	*Load%*
CBL-1	BGE Switchgear	BUS-0123	FDR	0	23.51	536.67	6.53
XFMR-SWB	BUS-0123	P-SWB	TX2	2.93	23.52	536.76	35.84
CBL-14	QSWB	P-SWB	FDR	0.34	558.65	451.66	24.5
XFMR-TDPB	BUS-0127	BUS-0125	TX2	0.66	356.78	287.36	59.32
CBL-2	P-SWB	BUS-0127	FDR	0.03	356.78	287.44	46.95
CBL-16	P-DPB	P-RPB	FDR	0.13	152.98	52.97	66.51
CBL-17	P-DPB	P-R1	FDR	0.17	34.73	12.03	9.14
CBL-18	P-R1	P-R1A	FDR	0.09	34.73	12.01	17.37
CBL-19	P-R1A	P-R1C	FDR	1.56	34.73	11.99	----
CBL-15	BUS-0125	P-DPB	FDR	0.1	823.34	285.38	66.4
CBL-20	P-DPB	P-RP2	FDR	1.65	41.72	14.45	36.28
CBL-21	P-DPB	P-KL2	FDR	0.67	214.33	74.22	56.4
CBL-22	P-DPB	P-KL2A	FDR	0.89	283.02	98	74.48
CBL-23	P-DPB	P-CS1	FDR	0.41	96.58	33.44	55.19
CBL-26	P-MP4	BUS-0128	FDR	0.09	42.03	33.81	36.55
CBL-27	P-MP4	BUS-0129	FDR	0.16	15.77	12.69	31.55
CBL-28	P-MP4	BUS-0131	FDR	0.33	7.9	6.35	22.57
CBL-29	P-MP4	BUS-0132	FDR	0.21	3.53	2.84	14.11
CBL-30	P-MP4	BUS-0133	FDR	0.03	0.88	0.71	3.52
CBL-31	P-MP4	BUS-0137	FDR	0.26	5.26	4.23	21.05

Branch Name	*From*	*To*	*Type*	*VD%*	*Amps*	*kVA*	*Load%*
CBL-32	P-MP4	BUS-0138	FDR	0.34	5.27	4.24	21.07
CBL-33	P-MP4	BUS-0139	FDR	0.35	10.54	8.47	30.1
CBL-34	P-MP4	BUS-0140	FDR	0.27	5.26	4.23	21.06
CBL-35	P-MP4	BUS-0141	FDR	0.7	10.58	8.51	30.21
CBL-36	P-MP4	BUS-0142	FDR	0.55	5.28	4.25	21.12
CBL-37	P-MP4	BUS-0143	FDR	0.14	3.15	2.54	12.62
CBL-38	P-MP4	BUS-0144	FDR	0.14	21.03	16.91	18.28
CBL-39	P-MP4	BUS-0145	FDR	0.22	26.31	21.16	30.95
CBL-40	P-MP4	BUS-0146	FDR	0.17	7.89	6.34	15.78
CBL-3	P-SWB	P-MP4	FDR	0.16	170.56	137.41	44.88
XFMR-TRP4	BUS-0135	BUS-0134	TX2	3.92	68.38	55.01	37.9
CBL-48	P-LP4	P-DM4	FDR	0.17	10.71	8.62	16.47
CBL-41	P-LP4	BUS-0135	FDR	0.01	68.38	55.02	22.06
CBL-42	BUS-0134	P-RP4	FDR	0.14	161.75	54.11	52.18
CBL-45	P-RP4	P-RP3	FDR	0.19	149.11	49.8	64.83
CBL-46	P-RP4	P-RP4A	FDR	0.04	12.64	4.22	11
CBL-47	P-RP4A	P-DM4A	FDR	0.47	12.64	4.22	19.45
CBL-4	P-SWB	P-LP4	FDR	0.13	79.09	63.72	20.81
CBL-5	P-SWB	P-KH2	FDR	0.25	127.3	102.56	33.5
CBL-6	P-SWB	P-LPB	FDR	0.02	13.04	10.5	8.69
CBL-7	P-SWB	P-LP1	FDR	0.07	9.44	7.61	6.29
CBL-8	P-SWB	P-LP2	FDR	0.05	11.18	9	7.45
CBL-9	P-SWB	P-SMB	FDR	0.03	121.19	97.63	52.69
CBL-51	P-MPB	BUS-0147	FDR	0.06	0.79	0.27	3.17
CBL-52	P-MPB	BUS-0063	FDR	0.02	0.4	0.13	1.58
CBL-53	P-MPB	BUS-0066	FDR	0.03	0.54	0.18	2.15
CBL-54	P-MPB	BUS-0065	FDR	0.46	8.42	2.85	33.7

Branch Name	From	To	Type	VD%	Amps	kVA	Load%
CBL-55	P-MPB	BUS-0064	FDR	0.04	0.54	0.18	2.15
CBL-50	BUS-0062	P-MPB	FDR	0.03	10.66	3.6	21.33
XFMR-TMPB	BUS-0067	BUS-0062	TX2	2.9	4.51	3.62	12.49
CBL-49	P-MDB	BUS-0067	FDR	0.01	4.51	3.62	6.94
CBL-56	P-MDB	BUS-0068	FDR	0.02	1.76	1.42	7.05
CBL-57	P-MDB	BUS-0069	FDR	0.03	1.76	1.42	7.05
CBL-58	P-MDB	BUS-0070	FDR	0.04	1.76	1.42	7.05
CBL-59	P-MDB	BUS-0071	FDR	0.46	15.83	12.73	45.23
CBL-60	P-MDB	BUS-0072	FDR	0.36	15.81	12.71	45.19
CBL-61	P-MDB	BUS-0073	FDR	0.24	26.33	21.16	40.5
CBL-62	P-MDB	BUS-0074	FDR	0.21	26.32	21.16	40.49
CBL-63	P-MDB	BUS-0078	FDR	0.35	10.54	8.47	30.12
CBL-64	P-MDB	BUS-0077	FDR	0.27	5.27	4.23	21.07
CBL-65	P-MDB	BUS-0075	FDR	0.09	21.03	16.9	42.06
CBL-66	P-MDB	BUS-0076	FDR	0.12	21.03	16.91	42.07
CBL-67	P-MDB	BUS-0079	FDR	0.02	1.17	0.94	4.7
CBL-68	P-MDB	BUS-0080	FDR	0.15	5.26	4.23	21.04
CBL-69	P-MDB	BUS-0082	FDR	0.22	26.32	21.16	30.97
CBL-70	P-MDB	BUS-0081	FDR	0.33	10.54	8.47	30.11
CBL-10	P-SWB	P-MDB	FDR	0.22	194.92	157.04	51.3
CBL-73	BUS-0088	P-EPB	FDR	0.02	8.48	2.8	13.04
XFMR-TEPB	BUS-0089	BUS-0088	TX2	5.18	3.5	2.82	19.39
CBL-72	P-EB	BUS-0089	FDR	0.01	3.5	2.82	9.99
ATS-1	BUS-0114	BUS-0096	FDR	0	3.5	2.82	----
ATS-2	BUS-0113	BUS-0099	FDR	0	47.15	37.97	----
CBL-74	BUS-0091	P-SB	FDR	0.03	47.15	37.97	41
CBL-75	P-SB	BUS-0083	FDR	0.17	5.25	4.23	21.02

Branch Name	From	To	Type	VD%	Amps	kVA	Load%
XFMR-TSPB	BUS-0149	BUS-0094	TX2	5.05	42.13	33.91	77.84
CBL-77	BUS-0094	P-SPB	FDR	0.05	99.66	32.94	66.44
CBL-11	P-SWB	BUS-0096	FDR	0.01	3.5	2.82	3.04
CBL-71	BUS-0097	P-EB	FDR	0	3.5	2.82	3.04
CBL-12	P-SWB	BUS-0099	FDR	0.05	47.15	37.99	31.43
CBL-78	P-SPB	P-SP1	FDR	1.39	39.65	13.1	46.64
CBL-79	P-SPB	P-SP2	FDR	1.05	60.02	19.83	70.61
CBL-13	P-SWB	BUS-0103	FDR	0.07	56.21	45.29	37.47
AUTO-0003	BUS-0115	BUS-0103	FDR	0	56.21	45.25	UNKOWN
CBL-80	BUS-0104	P-VB	FDR	0.15	56.21	45.25	48.88
XFMR-TVPB	BUS-0106	BUS-0108	TX2	6.93	14.45	11.61	80.07
CBL-81	P-VB	BUS-0106	FDR	0.05	14.45	11.61	41.27
CBL-82	BUS-0108	P-VPB	FDR	0.1	35	11.31	70.01
CBL-83	P-VB	BUS-0110	FDR	0.54	21.13	16.98	42.25
CBL-84	P-VB	BUS-0112	FDR	1.18	10.63	8.55	42.53
CBL-85	P-VB	BUS-0111	FDR	0.74	10.59	8.51	30.24
CBL-88	BUS-0116	BUS-0113	FDR	0	0	0	0
CBL-86	BUS-0120	BUS-0114	FDR	0	0	0	0
CBL-90	BUS-0117	BUS-0115	FDR	0	0	0	0
CBL-87	WIREWAY	BUS-0120	FDR	0	0	0	0
CBL-89	WIREWAY	BUS-0116	FDR	0	0	0	0
CBL-91	WIREWAY	BUS-0117	FDR	0	0	0	0
CBL-92	BUS-0122	WIREWAY	FDR	0	0	0	0
CBL-76	P-SB	BUS-0149	FDR	0.01	42.13	33.91	36.64

Arc Fault Rating

Using SKM, an arc flash study was conducted. The results showed that the additional quick connect switchboard along with the main distribution panel require a complete Arc Flash Suit. The main switchboard requires a minimum of Arc-rated Shirt and Pants. See the next page for complete Arc Flash results.

	Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category	Label #	Cable Length From Trip Device (ft)	Incident Energy at Low Marginal	Incident Energy at High Marginal
1	BGE Switchgear	F-UTILITY	13.20	3.25	3.22	2.89	2.86	0.008	0.000	No	SWG	153	1	36	0.04	Category 0	# 0001			
2	P-CS1	CB-CS1	0.208	11.70	4.86	11.70	4.86	0.017	0.000	Yes	PNL	25	7	18	0.25	Category 0	# 0002	50.00		
3	P-DM4	DM4	0.48	4.77	3.48	4.77	3.48	0.017	0.000	Yes	PNL	25	6	18	0.18	Category 0	# 0003	100.00		
4	P-DM4A	DM4A	0.208	1.76	1.09	1.76	1.09	0.407	0.000	Yes	PNL	25	18	18	1.2	Category 1 (*N3)	# 0004	100.00		
5	P-DPB	CB-DPB	0.208	20.00	6.01	20.00	6.01	2	0.000	Yes	PNL	25	148	18	38	Category 4 (*N3) (*N9)	# 0005			
6	P-EB	CB-EB	0.48	24.97	14.33	24.97	14.33	0.017	0.000	Yes	PNL	25	14	18	0.83	Category 0	# 0006			
7	P-EPB	CB-EPB	0.208	1.33	0.89	1.33	0.89	2	0.000	Yes	PNL	25	42	18	4.9	Category 2 (*N3) (*N9)	# 0007			
8	P-KH2	CB-KH2	0.48	21.99	12.86	21.99	12.86	0.017	0.000	Yes	PNL	25	13	18	0.73	Category 0	# 0008	120.00		
9	P-KL2	CB-KL2	0.208	9.94	4.33	9.94	4.33	0.017	0.000	Yes	PNL	25	6	18	0.22	Category 0	# 0009	135.00		
10	P-KL2A	CB-KL2A	0.208	9.94	4.33	9.94	4.33	0.017	0.000	Yes	PNL	25	6	18	0.22	Category 0	# 0010	135.00		
11	P-LP1	LP1	0.48	11.26	7.25	11.26	7.25	0.017	0.000	Yes	PNL	25	9	18	0.39	Category 0	# 0011	150.00		
12	P-LP2	LP2	0.48	15.27	9.42	15.27	9.42	0.017	0.000	Yes	PNL	25	11	18	0.52	Category 0	# 0012	100.00		
13	P-LP4	CB-LP4	0.48	23.69	11.64	23.69	11.64	0.017	0.000	Yes	PNL	25	12	18	0.65	Category 0 (*N3)	# 0013	100.00		
14	P-LPB	LPB	0.48	28.06	15.83	28.06	15.83	0.017	0.000	Yes	PNL	25	15	18	0.91	Category 0	# 0014	30.00		
15	P-MDB	MDB	0.48	26.22	14.94	25.15	14.33	0.017	0.000	Yes	PNL	25	15	18	0.85	Category 0	# 0015	80.00		
16	P-MP4	MP4	0.48	27.21	15.42	26.28	14.89	0.016	0.000	Yes	PNL	25	15	18	0.87	Category 0	# 0016	70.00		
17	P-MPB	CB-MPB	0.208	1.74	1.08	1.71	1.06	1.537	0.000	Yes	PNL	25	41	18	4.6	Category 2 (*N3)	# 0017			
18	P-R1	CB-R1	0.208	7.95	3.70	7.95	3.70	0.018	0.000	Yes	PNL	25	6	18	0.20	Category 0	# 0018	200.00		
19	P-R1A	R1A	0.208	6.57	3.24	6.57	3.24	0.017	0.000	Yes	PNL	25	5	18	0.16	Category 0	# 0019	42.00		
20	P-R1C	R1C	0.208	0.96	0.71	0.96	0.71	0.49	0.000	Yes	PNL	25	16	18	0.94	Category 0 (*N3)	# 0020	56.00		
21	P-RP2	CB-RP2	0.208	2.30	1.55	2.30	1.55	2	0.000	Yes	PNL	25	61	18	8.8	Category 3 (*N9)	# 0021	235.00		
22	P-RP3	RP3	0.208	6.61	3.25	6.61	3.25	0.017	0.000	Yes	PNL	25	5	18	0.16	Category 0	# 0022	20.00		
23	P-RP4	CB-RP4	0.208	7.13	2.92	7.13	2.92	0.025	0.000	Yes	PNL	25	6	18	0.22	Category 0 (*N3)	# 0023			
24	P-RP4A	RP4A	0.208	6.06	3.06	6.06	3.06	0.017	0.000	Yes	PNL	25	5	18	0.16	Category 0	# 0024	20.00		
25	P-RPB	CB-RPB	0.208	17.39	6.41	17.39	6.41	0.017	0.000	Yes	PNL	25	8	18	0.34	Category 0	# 0025	16.00		
26	P-SB	CB-SB	0.48	25.56	14.62	25.53	14.60	0.017	0.000	Yes	PNL	25	15	18	0.85	Category 0	# 0026			
27	P-SMB	SMB	0.48	35.28	19.25	35.28	19.25	0.017	0.000	Yes	PNL	25	17	18	1.1	Category 0	# 0027	10.00		
28	P-SP1	SP1	0.208	1.44	0.95	1.44	0.95	0.706	0.000	Yes	PNL	25	23	18	1.8	Category 1 (*N3)	# 0028	150.00		
29	P-SP2	SP2	0.208	2.02	1.20	2.02	1.20	0.436	0.000	Yes	PNL	25	20	18	1.5	Category 1 (*N3)	# 0029	75.00		
30	P-SPB	CB-SPB	0.208	3.30	1.70	3.30	1.70	0.579	0.000	Yes	PNL	25	30	18	2.8	Category 1 (*N3)	# 0030			
31	P-SWB	CB-SWB Main	0.48	37.73	20.39	22.24	12.02		0.000	Yes	PNL	25	43	18	5.0	Category 2	# 0031	225.00		
32	P-VB	CB-VB	0.48	18.38	11.03	18.20	10.92	0.017	0.000	Yes	PNL	25	12	18	0.63	Category 0	# 0032			
33	P-VPB	CB-VPB	0.208	1.29	0.88	1.29	0.88	2	0.000	Yes	PNL	25	42	18	4.8	Category 2 (*N3) (*N9)	# 0033			
34	QSWB	CB-QSWB	0.48	35.57	18.12	21.46	10.93		0.000	Yes	SWG	32	249	24	38	Category 4 (*N2) (*N9)	# 0034			
35	WIREWAY	CB-G	0.48	1.28	1.13	1.28	1.13	2	0.000	Yes	PNL	25	50	18	6.3	Category 2 (*N9)	# 0035	180.00		
36	Category 0: Nonmelting, Flammable Materials with Weight >= 4.5 oz/sq yd	0.0 - 1.2 cal/cm^2													#Cat 0 = 23	(*N2) < 80% Cleared Fault Threshold				

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	Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category	Label #	Cable Length From Trip Device (ft)	Incident Energy at Low Marginal	Incident Energy at High Marginal
37	Category 1: Arc-rated FR Shirt & Pants	1.2 - 4.0 cal/cm^2													#Cat 1 = 4	(*N3) - Arcing Current Low Tolerances Used				
38	Category 2: Arc-rated FR Shirt & Pants	4.0 - 8.0 cal/cm^2													#Cat 2 = 5	(*N9) - Max Arcing Duration Reached				
39	Category 3: Arc-rated FR Shirt & Pants & Arc Flash Suit	8.0 - 25.0 cal/cm^2													#Cat 3 = 1					
40	Category 4: Arc-rated FR Shirt & Pants & Arc Flash Suit	25.0 - 40.0 cal/cm^2													#Cat 4 = 2					
41	Category Dangerous!: No FR Category Found	40.0 - 999.0 cal/cm^2													#Danger = 0	IEEE 1584 - 2002/2004a Edition Bus Report (80% Cleared Fault Threshold, include Ind. Motors for 5.0 Cycles), mis-coordination not checked				

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Summary

The new lighting design offers a new perspective on the building. Originally the lighting design offered a great deal of energy savings. Through the redesign, power density and energy savings were met while providing decorative lighting throughout the space. West Village Commons can stand out at night and during the day as a premiere space on campus. Student's enjoyment of the building has always be the primary design criteria throughout the project. Blending in with the night sky can make this building very unique for any visitor, student or faculty of the campus.

The electrical redesign work showed a change in feeder size, but the overall lighting power scheme remained simple and efficient. The original design offered a lighting panel per floor. Throughout the redesign, the spares originally placed on these boards were used. Through running the SKM analysis of the system, the load flow of the building was on target and did not stress any feeders.

The PV analysis proved to be more efficient than the typical inverter based system. A few key pieces still need to be brought to market to make direct coupling effective. For the current system to use DC, a battery system would need to be installed within the building which can be very costly and force code issues. DC lighting did show that it can provide the proper illuminance values while using less energy than the typical AC ballast. To place the PVs on the roof would be a very easy task to accomplish through a ballast racking system. The existing joist conditions withstand the additional loading of a photovoltaic array and its determined spacing.

Finally, the student lounge received automatic shade devices with open loop sensors and dimming for the balcony and under balcony lighting. The dimming systems offered savings throughout the year while the shades reduced illuminance above 2000 lux, or the upper threshold of useful illuminance. Along with the RTSM analysis, the Daysim runs proved how valuable shading is. The RTSM Annual Cooling Load calculation saw a tremendous reduction in load when shades were applied. This would provide a more suitable and comfortable study lounge for students to enjoy.

Resources

Software

- Autodesk AutoCAD 2011
- AGi32 v2.1
- DAYSIM – Penn State Version
- PVWatts v1.1
- SKM Power*Tools v6.5
- TRNSYS 16.1 Simulation Studio – Courtesy of the Brownson Group

Materials

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